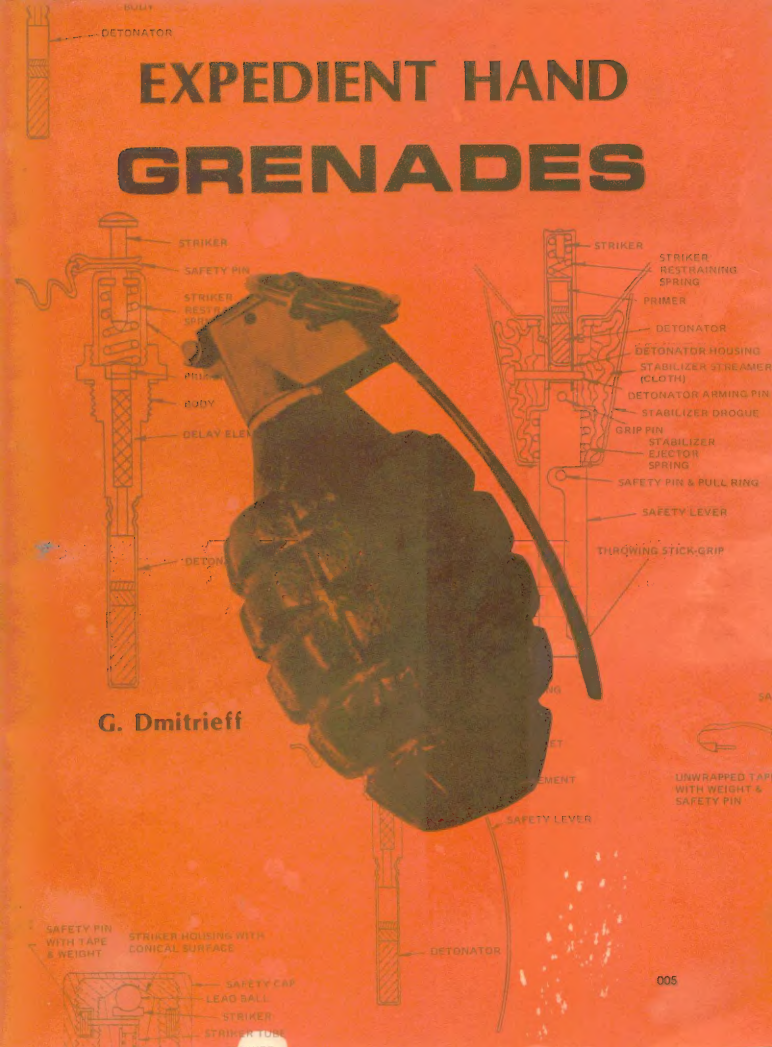
EXPEDIENT HAND GRENADES



G. Dmitrieff

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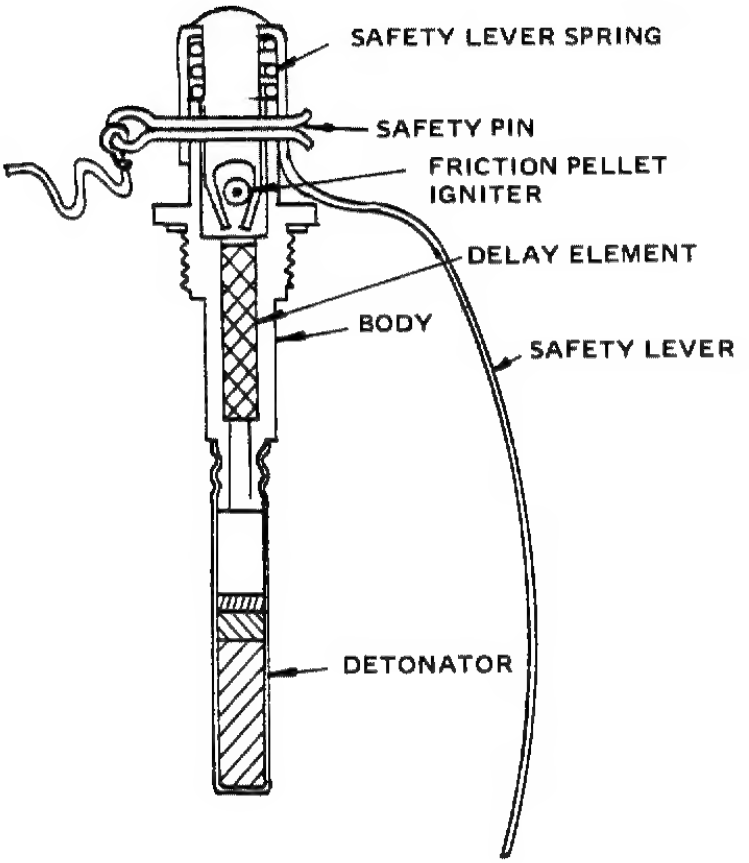

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WARNING

The manufacture of any of the grenades shown herein without the proper federal license is in violation of federal law and could result in a prison sentence, fine, or both. Manufacture of said devices may also be in violation of state laws and local ordnances as well, even though a person or firm has the proper federal license. The manufacture of any explosive or incendiary device can be extremely dangerous unless carried out by trained professionals operating under the strictest safety standards and should not be attempted on an amateur basis. The information presented herein is offered in the academic spirit of dissemination of knowledge only and the author and publisher neither condone nor accept any responsibility for the illegal or unsafe use of said information.

Introduction

Thanks to movies, television and the frequency of wars, both small and large, very few individuals would not recognize a hand grenade.

How the grenade functions, what kinds there are, how they are made, etc., are questions answered only in special technical manuals which are generally not available to the public at large.

Even fewer people would know the term "expedient grenade". Yet "expedient" simply means that the grenade is made from the best materials available at the given time and place, and assembled by persons without special technical training.

Such a grenade need not necessarily be inferior in safety or performance to the standard type. A properly designed expedient grenade may require more material and labor to produce it and it may require slightly more training to operate, but it can be as safe and as effective as some of the grenades currently used by various armies around the world.

It is a historical fact that one of the first objectives of any occupation force is the disarming of the local population. This was practiced by Julius Caesar in 50 BC, Napoleon in the 1800's and Hitler in the 1940's and will be practiced in the future.

In modern times such disarmament consists of confiscation of arms, ammunition and explosives; eliminating or severely retricting the manufacture of these items and last, but not least, the taking into custody or liquidation of all persons skilled in their manufacture (gunsmiths, explosive technicians, chemists, etc.). The objective of this book is to describe the manufacture of expedient grenades with equipment and methods that are so simple as to be easily mastered by almost anyone. Rather than a general textbook covering the entire spectrum of hand grenades, it is a handbook describing in detail only the two optimum models for expedient manufacture.

The expedient hand grenade utilizes components readily available to the manufacturer, hence the variety is practically unlimited. However, there are some common guidelines which apply.

Firstly — the equipment, facilities, technical skills and the work personnel are limited, when compared to commercial or government operations. Therefore only the most cost-effective and casualty/damage inflicting grenades should be produced.

This consideration reduces the grenade choice to two types only:

a. Fragmentation
b. Incendiary

The sometimes expounded theory of an *expedient training grenade* made from a stone of appropriate size and weight, and painted yellow for easy recovery, or a cement-filled beer can does not even merit discussion.

The *offensive-blast grenade* is not recommended for several reasons. It requires a relatively large quantity of high explosive filler yet has only limited effect when compared to the fragmentation grenade. Since the HE filler is the most difficult material to obtain it must be used wisely for maxi-

mum effect. The amount of filler for one offensive grenade will serve in four to five fragmentation grenades with a much better effect.

A *gas grenade* is more of a handicap to the thrower who has no gas mask than to the target who usually does have one.

Secondly — commercially available items not requiring purchase permits are preferable for manufacturing expedient devices. For example: colored smoke, or signal grenades, may usually be substituted by such items as road emergency flares, marine signals, photo flash devices, amusement fireworks, etc. Hence an expedient smoke or signal hand grenade is unnecessary.

Thirdly — simplicity is the ultimate sophistication. Flashing lights and electronic gadgets are no substitute for common sense, sound engineering design and careful attention to details during manufacture. Laboratory experiments may produce fancy electric piezo-crystal actuated fuze, but the end-user prefers a striker-initiated delay-type model which works reliably.

Lastly, the reader is cautioned that the techniques described herein are dangerous due to the explosive nature of the materials. Furthermore, construction and possession of hand grenades is subject to various Federal, State and local laws and requires a special "destructive devices" manufacturing license.

Throughout the text, descriptions by types of systems are indicated by a letter code while descriptions and details of manufacture by components are indicated by numbers. The letter "E" is reserved for expedient items.

Grenade Types

Before becoming involved with the design and manufacture of an expedient grenade, a review of the types and characteristics of the various grenades in use is in order. A thorough understanding of their features and components gives the designer a better insight into the DO's and DON'T's which should be observed.

The hand grenade is an important personal weapon which is most suitable for close combat. Its tactical advantages are:

1. Projection at throwing ranges is silent.
2. Detection of thrower is difficult (almost impossible at night).
3. It is an area weapon, thus movement and/or noise in the general target area is adequate for aiming.

Hand grenades are generally classified into the following categories:

A. Training
B. Practice
C. Chemical
D. Defensive (fragmentation)
O. Offensive (blast)

Training grenades include both simulators and dummy and are constructed of the same basic materials (except for the filler, which is sand or cement) and with the same physcial characteristics (shape, weight, balance, etc.) as a fragmentation model. A training grenade is completely inert.

Practice grenades contain a small charge of black powder inserted in the filler cavity which is closed with a cork.

Chemical grenades are highly specialized and include the following:

a. Smoke — produces white smoke for screening or signaling. They usually burn about 2 minutes.
b. Signal — produces colored smoke for signaling: red, green, yellow, violet. Signal grenades burn about 1 minute.
c. Gas — tear gas irritant mix (tear and vomit gas) for harassing enemy troops and civil disturbance control, burns about 1 minute.
d. WP — white phosphorous filler is dispersed by the explosion of a detonating fuze, producing burning phosphorous particles over a 15 meter radius; generates a dense white smoke screen and will cause burn casualties.
e. Incendiary — thermite filler burns at 2400° C for 30-35 seconds.

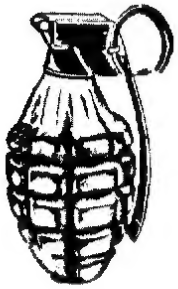
Defensive (fragmentation) grenades produce fragments with a casualty radius of 10 meters, requiring cover for the thrower. These grenades are designed to kill or incapacitate with high velocity fragments, hence the blast effect is secondary only. Depending on the size and form of fragments, the effective radius is about 15 meters. However, individual fragments may travel as far as 150 meters. The defensive-fragmentation grenade is the most common and generally the most effective type of grenade in use.

Offensive (blast) grenades are of antipersonnel and antitank type. In its antipersonnel application it requires no cover for the thrower since the explosive effect produces casualties within a radius

HAND GRENADE CLASSIFICATION

TRAINING

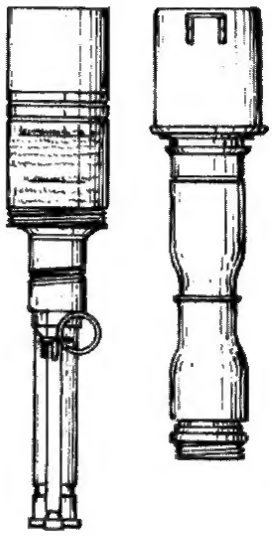
SIMULATORS
DUMMY



PRACTICE

OFFENSIVE (BLAST)

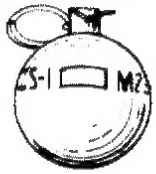
ANTIPERSONNEL
ANTITANK

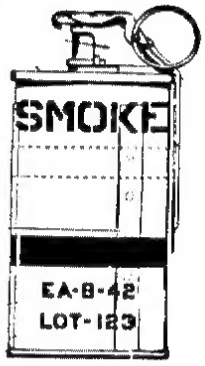


DEFENSIVE (FRAGMENTATION)

CHEMICAL

SMOKE
SIGNAL
GAS
INCENDIARY
ILLUMINATING
MARINE MARKER





(Grenades shown are indicative of type only and are not to scale.)

of 5 meters. When used as an antitank weapon, the offensive grenade has a shaped charge effect.

Unlike the fragmentation grenade, the blast grenade is designed to kill or incapacitate by explosive blast only. Indeed, its limited effective range makes it possible for the thrower to advance without waiting for the grenade to explode. It is suitable for use by personnel in exposed and/or attack position.

Design characteristics of offensive grenades include:

Fuze: the same types and models as used in defensive-fragmentation grenades.

Body: light construction adequate to protect the filler from weather and handling. Light sheet metal, plastic or waterproofed cardboard are used.

Filler: HE with maximum specific brisance is desirable. Because of the absence of a heavy body and/or fragmentation sleeve, the charge can be increased without an increase in the overall grenade weight.

The low efficiency of a blast grenade is due to the fact that the blast energy decreases with the cube of the distance, i.e., tripling the distance from the explosion center reduces the blast force by a factor of 9.

Because of the relatively large main charge and the low effect, offensive grenades are not used extensively in expedient designs.

The offensive grenade is of limited effectiveness except in closed spaces (inside buildings, caves, vehicles, etc.). In design, care must be taken to avoid large and heavy components which can act as fragments. A typical offensive grenade contains about 200 grams of pressed HE (usually TNT). The body is constructed from laminated paper-sheet metal to eliminate fragmentation.

Ideally, the offensive-blast grenade should detonate within the fuze specification time limit without evidence of bursting charge pieces.

HEAT grenades were developed during World War II as an individual defense against armored vehicles. Their range was very short and armor penetration limited. HEAT grenades have been replaced by a variety of expendable one shot rocket launchers of the *Panzerfaust* type, one example being the US Army M72A1 LAW (Light Antiarmor Weapon).

The HEAT hand grenade is essentially a shaped charge with or without a stand-off cone with a simple, impact, mechanical oriented fuze in the back of the grenade. The grenade is oriented in flight by streamers, generally made of cloth, stored in the grip.

Removal of the safety pin permits release of the safety lever. When the safety lever is released, the streamer cone is free to fall back, pulling the cloth streamer stabilizers and allowing the fuze safety pin to drop out. Upon impact the detonator assembly moves forward, forcing the primer against a stationary firing pin. The primer ignites the detonator which in turn explodes the shaped charge.

BASIC PARAMETERS

A good hand grenade must have the following parameters:

1. Safety — the grenade must not arm or explode when dropped accidentally, particularly when the thrower is in the act of of throwing. Most grenades use the proven system of striker arm control by a lever shaped to be gripped by the hand holding the grenade. However, the grenade is initiated by a time fuze instead of a graze fuze. The time fuze method of initiation is perfectly safe for normal handling and presents a negligible risk of accidental explosion right up to the moment of throwing. With the safety pin removed, the grenade arms at the moment of leaving the hand regardless of whether such movement is accidental or intentional. Once the pin is removed, the grenade is to be considered in an unsafe condition.
2. Reliability — the fuze must assure positive ignition and explosion. The time fuze initiation is quite reliable. Once the striker lever has been released and the fuze started to burn, subsequent movements of the grenade whether rolled, thrown, dropped, or simply put down, has no effect on the explosive chain.
3. Simplicity — the grenade must be simple to use, requiring minimum training. Although the simplicity of operation is of high importance, the ease of manufacture must be considered. Use of simple forms and readily available materials are essential. Grenade designs must be simple.
4. Handling — such operations as fuzing, safety pin removal and replacement must be easy and capable of being performed by gloved hands. Today's grenades us simple, suitably shaped and sized components. The majority of grenades are stored already fuzed and the pull rings of safety pins are large enough to accommodate a gloved finger.
5. Arming — ideally a grenade should arm after it has left the thrower's hand. Lever-actuated time fuze arms at the instant of removal of restraint on the safety lever. The fuze ignites and no normal process can prevent the grenade from exploding.
6. Fragmentation — maximum percentage of the grenade's weight should act as fragments. These fragments should be of optimum size for effective casualty production within a given radius. Old types used a cast iron body which gave uneven fragment size and pattern. New fragmentation technique uses definite size particles inside a thin-walled body or plastic matrix rather than relying on the wall itself to break into fragments. Fragmentation grenades are required to function within the fuze specification time limit with complete detonation without evidence of bursting charge pieces or large fragments of fragment coil and/or prenotched body.

6a. Incendiary grenade — the filler must burn completely within 40 seconds after the fuze initiation. Note: during this test the pesonnel must wear eye protection as the burning filler produces intense flame.

7. Weight — for hand throwing to a safe and reasonable distance the overall grenade weight should not exceed 350 grams. Due to better fragmentation control and use of more powerful explosives, it is possible to reduce the grenade overall weight without a substantial reduction in its effectiveness. The use of aluminum alloy in fuze components can reduce the weight even further.

8. Storage — the components and assembled grenade should be impervious to ambient climatic conditions, moisture, temperature, magnetic field, etc. Deterioration due to prolonged storage even at elevated temperatures should be minimal. Use of high impact plastics, non-ferrous metals and newer explosives improves the storage life of new types of grenades.

The performance of a fragmentation grenade is best compared to that of a shotshell. The same basic parameters apply to both, since they have the same objective:

I. To hit the target with the maximum number of fragments.
II. The fragments should be uniform in size and weight and possess high residual energy (velocity) for deep penetration and effect.

The first objective is broken down into: 1) range and accuracy and 2) uniform, dense pattern of fragments.

The second objective is again broken down into: 1) large and heavy fragments and 2) high residual fragment velocity.

When considering these objectives, certain parameters emerge as fixed and non-variable. These are:

a. Target size: both a duck and a man have a definite target area which for all practical purposes is assumed fixed; a man-size target used for small arms practice has an area of one half to .58 meters square (depending on the branch of the armed forces).
b. Minimum casualty energy: this area is easy for a duck, it requires a minimum of five pellets of No. 4 shot to "kill" a duck at 55 meters. To incapacitate a man, the casualty effect, the type of wounds and their severity comprise the study of terminal ballistics. For our purposes it is assumed that a fragment which penetrates fully a clear pine board 1" thick at 55 meters will incapacitate a man at that range.

Other parameters, which are not fixed and depend only on the designer selection are:

a. Grenade weight: although there is a practical limit to this value, the weight of grenades in current use varies from 140 to 600 grams, just as shot shell loads vary for a given gauge.
b. Fragment size: the shot pattern disperses with increased range, hence it is desirable to have the largest number of pellets for a given total shot charge. This assures a minimum pattern density at long range. The very same applies to hand grenades.
c. Uniformity of pattern: a shot charge of deformed, non-uniform pellets (and even worse, of different sizes) is bound to have "windows" — areas of reduced pattern density. The same will happen with a grenade body of non-spherical form where the prenotching and marking of the fragments is not done carefully. This is further accentuated by the grenade's unstable trajectory and unpredictable fuze orientation.
d. Fragment form: although a jagged, sharp-edged fragment is fearful to behold, because of its poor aerodynamical form it loses velocity faster than a small sphere; consequently a spherical fragment will have a deeper penetration for a given weight than a sharp-edged one. For this reason, some European grenades actually have small steel pellets embedded in the plastic body matrix. It is desirable to have a large density of high velocity small fragments which are dangerous at short range from the target, but which represent no danger to the thrower. A high explosive filler is optimum for this purpose with a charge of 50 grams being sufficient.

Grenade Range And Accuracy

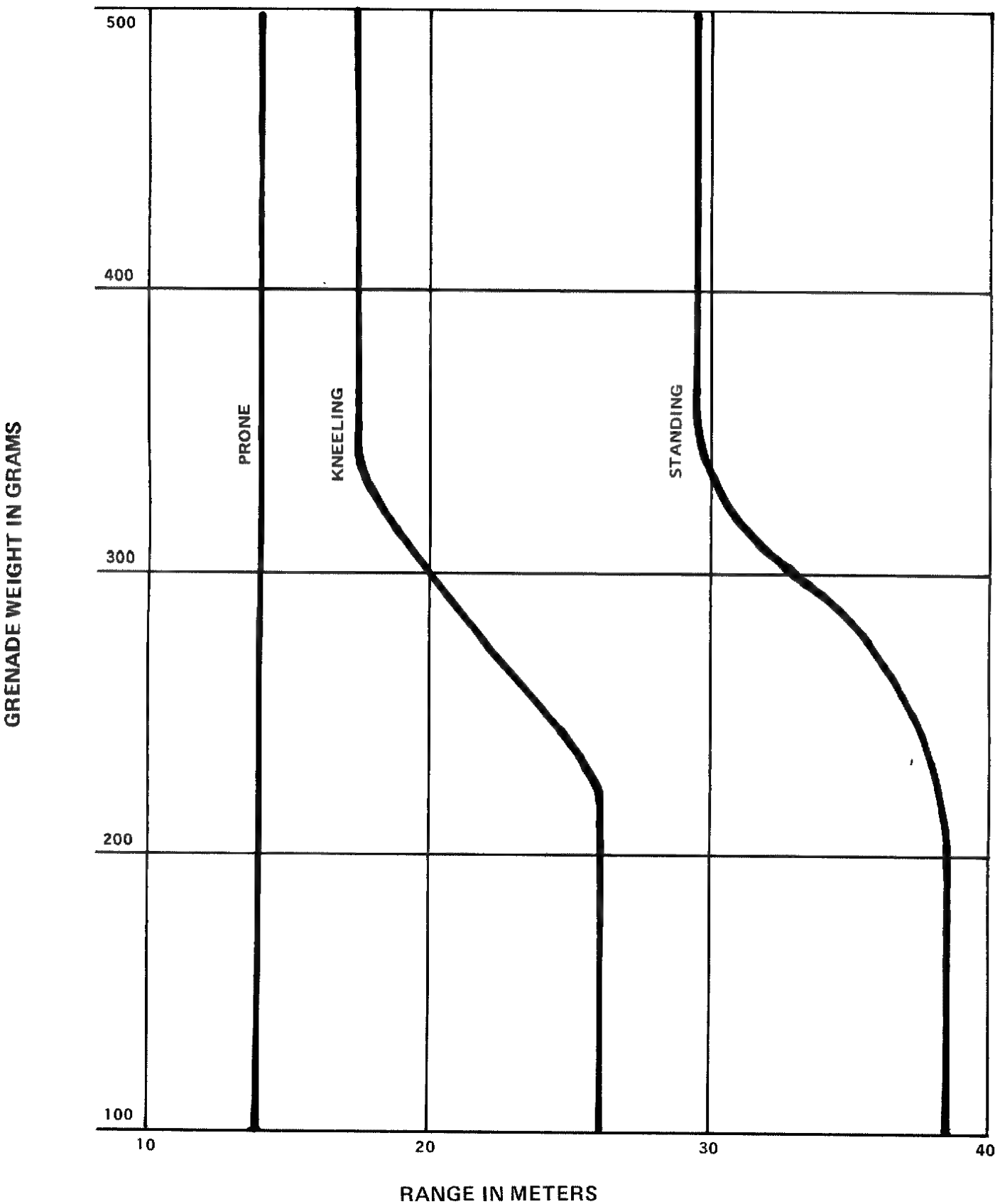
Although a small, light grenade may be thrown a relatively long distance, the higher initial velocity and the physical force required affect the impact accuracy to the point where 40 meters is accepted as the maximum effective range for a fragmentation grenade.

Grenade Weight

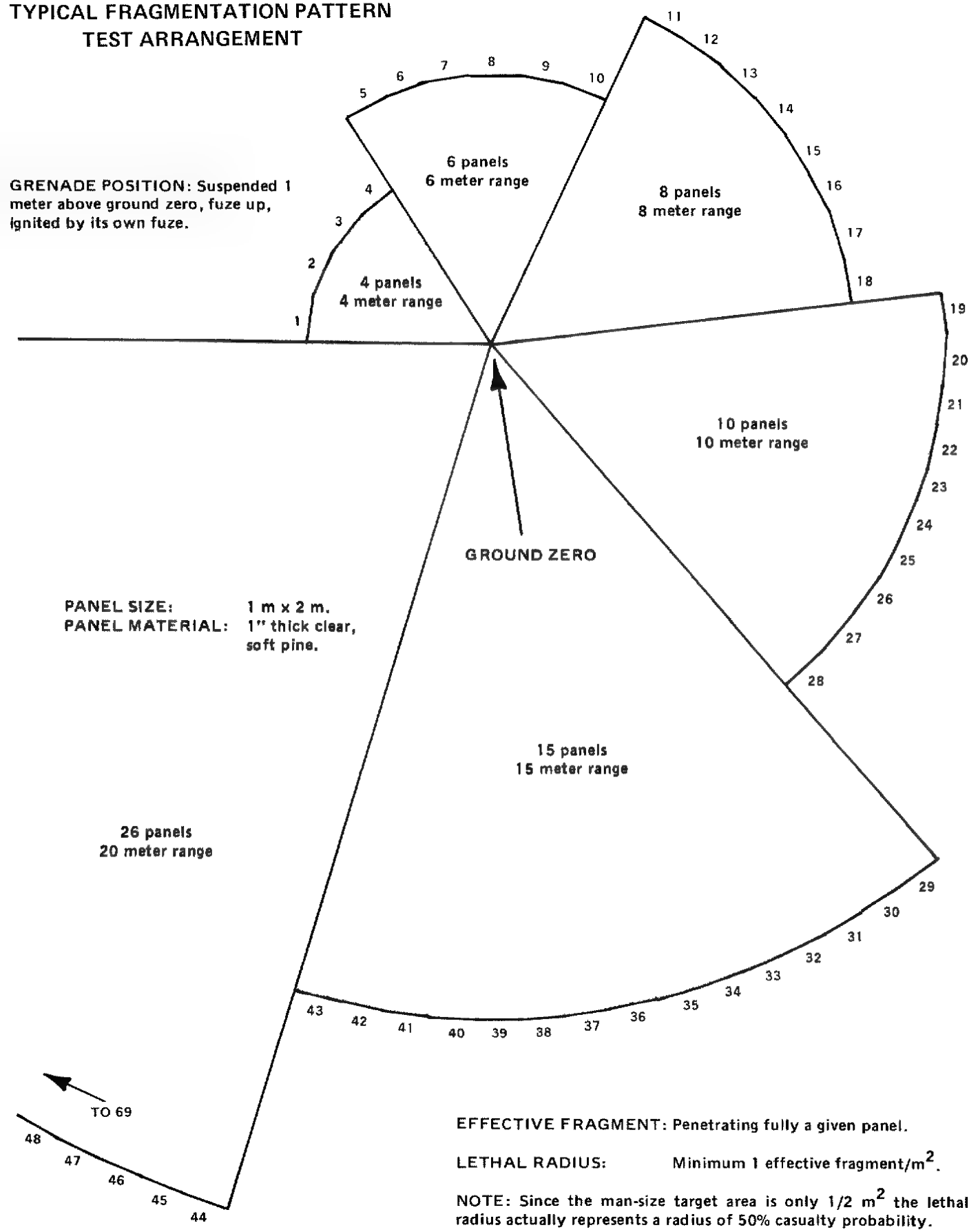
The older type fragmentation grenades were all in the 600-700 gram weight category.

Some new tests of weight vs. range for the three basic positions (prone, kneeling and standing) show that there are certain practical limits and grenades of 250 grams weight are selected as optimum. Heavier grenades have a reduced throwing range while lighter grenades which have an increased throwing range are handicapped by their reduced filler and fragmentation load.

AVERAGE EFFECTIVE RANGE OF A GRENADE FOR DIFFERENT THROWING POSITIONS



TYPICAL FRAGMENTATION PATTERN TEST ARRANGEMENT



EFFECTIVE FRAGMENT: Penetrating fully a given panel.

LETHAL RADIUS: Minimum 1 effective fragment/m^2.

NOTE: Since the man-size target area is only 1/2 m^2 the lethal radius actually represents a radius of 50% casualty probability.

This optimum weight is obviously not universally accepted as valid by the armed forces of numerous countries since the latest US model M67 grenade weighs 400 grams while the West German model DM 51 weighs 435 grams and the new Soviet RGD-5 weighs "only" 310 grams, still more than our ideal weight.

FUNCTION REQUIREMENTS:

1. Fragmentation efficiency/grenade weight.
2. Grenade weight/maximum effective range.
3. Effective casualty radius/maximum fragment radius.
4. Fragment lethality at target.
   a. Form.
   b. Weight.
   c. Velocity.
5. Fragment direction and density.

Some Design Considerations:

The World War I and World War II type fragmentation grenades used serrated, cast iron bodies which were impressive in size and appearance (US M2, British M36 and Soviet F1 models). Their reputations and efficiency were, however, greatly exaggerated. While their poor pattern density could leave targets untouched at ranges of a few yards, some individual fragments had a lethal range of 100-150 yards, requiring protection for the user. It was for this reason that fragmentation grenades were called "defensive" — to be used by personnel in trenches or behind cover, repelling targets moving in the open.

Extensive controlled tests performed on these grenades demonstrated that this type was far from optimum in performance.

Depending on the orientation of the grenade body at the time of the explosion, the fragment pattern varied from reasonably uniform if the grenade was vertical (fuze pointing straight up or straight down) to very poor if the grenade exploded in the horizontal position. In addition, the limited number of fragments (generally 40) left large, open gaps in the pattern.

These studies led to further investigations resulting in the complete reevaluation of the fragmentation casualty subject. It is expected that the increased use of body armor, better helmet materials and configuration and the extensive use of vehicular protection will require further reevaluation and/or redesign of antipersonnel grenades.

Controlled fragmentation and hence controlled lethal and maximum fragment radii eliminate the need for separate offensive and defensive type grenades.

The pattern and lethality test procedure is used because of the simple and convenient way of counting effective fragments.

The use of 1" thick soft pine boards to test penetration dates to pre-Civil War days. However, it is recognized that the actual wound mechanics on living tissue is quite different from the board penetration.

"Wound Ballistics", published by Surgeon General Lt. Gen. L. D. Heaton in 1962, is quite specific on this subject. However, when used judiciously and for comparison purposes only, the testing technique presented herein is a useful and valid tool.

Grenade Components

Starting in the 17th Century as a cast iron sphere filled with black powder and utilizing a match fuse, hand grenades eventually evolved into a variety of types.

Recent conflicts have stimulated critical re-evaluation of all types of individual weapons and tactics. The hand grenade is no exception to this reevaluation process. Traditional cast iron bodies, low powered fillers, random fragmentation and other previously accepted factors have been scrutinized. The immediate results of these studies have been smaller, lighter, yet more efficient grenades.

Regardless of the type and model, whether used in 1678 or 1978, a hand grenade consists of three basic elements: body, fuze (or fuse, depending on type) and filler. The close relationship between antiquated grenades and those of the latest design is clearly evident in the illustration on the following page. The construction, characteristics and features of these three components are:

BODY

A hand grenade body is the envelope which holds the filler, fuze and fragmentation assembly (when applicable) together. It must protect the filler and fuze from ambient climatic conditions (water, dust, dirt, etc.) and from physical damage due to rough handling, enemy action, etc.

A hand grenade body should have the following desirable features:

1. Light weight.
2. Imperviousness to adverse climatic conditions.
3. Non-rusting.
4. Water tight.
5. Coloring and/or marking should be integral with the body.
6. Easy to manufacture (not requiring complex tooling and/or sophisticated processes.
7. Easy to fill (inside cavity preferably to be cylindrical with a large opening).
8. Made from non-critical materials, available from a variety of sources.
9. Inexpensive.
10. Compatible with a variety of fillers without requiring special inside paint and/or lacquer.
11. Stability in storage for extended periods of time.

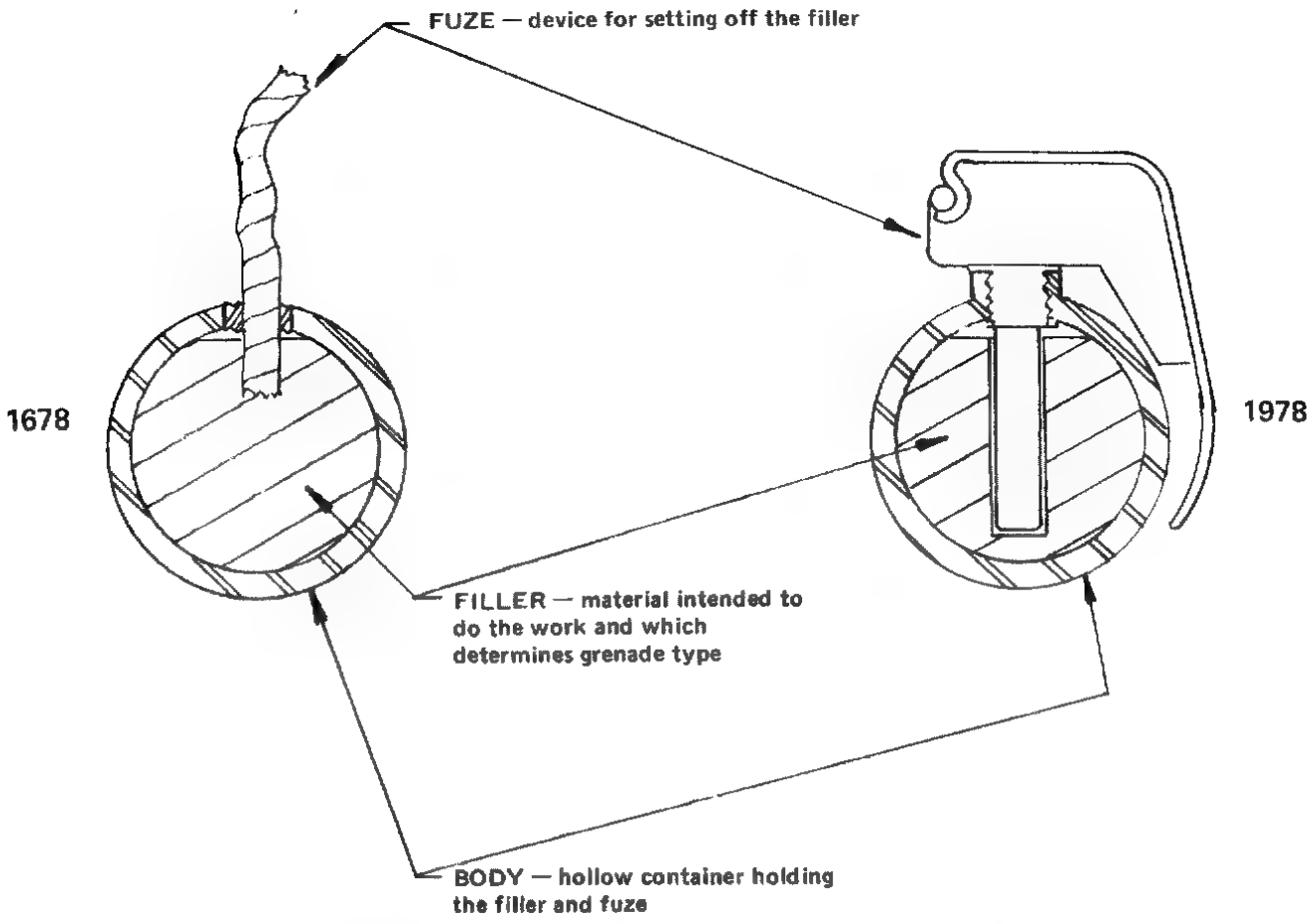
Obviously no one material and/or body form will satisfy all of the above requirements. However, rational evaluation of the most critical grenade parameters reduces the choices to a few only.

Traditionally, grenades made in the U.S. were of two basic types:

I. Egg/spherical — used in fragmentation grenades.
II. Cylindrical/cannister — used in all other types of grenades.

The reason for this division of shapes/types was based on practical requirements. The fragmentation grenade filler charge is only 100 to 150 grams of high explosive and the body/envelope is also the fragmentation system. Because the grenade throwing range is very important, the over-all weight of

EXPEDIENT HAND GRENADES



the grenade is kept low. Thus the grenade is small, yet effective.

On the other hand, the smoke, gas, incendiary and blast grenades require maximum filler capacity for best performance. The grenade throwing range and other parameters are secondary. If the bodies of these grenades were spherical they would be difficult to hold and throw by hand. Hence the bodies of non-fragmentation grenades are usually cylindrical, allowing good hand grip, yet large size of container.

Recently the above distinctions have somehow faded; some gas and illuminating grenades are of spherical form while some foreign-made fragmentation grenades are cylindrical.

The final choice of body shape depends on the material. Again, the fragmentation grenades were traditionally made from cast iron or pre-notched steel sheet. The other grenade types used a can form of construction of thin sheet metal or impregnated fiber sides with sheet steel tops and bottoms much like those on commercial soft drink cans.

With the advancement of plastics technology many of the new grenades use plastic bodies. Plastics offer so many advantages over the above traditional materials and forms that it is safe to assume they will become the grenade body material of the new models.

Following are descriptions of some traditional grenade bodies which indicate the problems involved in their manufacture.

FRAGMENTATION GRENADE BODY MATERIAL

Cast iron was traditionally the cheapest material with the simplest and most readily available manufacturing technology.

A heavy gage sheet steel with embossed fragment form and shaped into the body form is still the most efficient body construction.* Such a method, however, requires multiple operations, relatively expensive tooling and presses, plus welding and finishing machines. Furthermore, in spite of painting, the steel body is still subject to rusting.

* *It produces the maximum fragmentation for minimum body weight, all other parameters being equal.*

A body made of plastic with the fragments imbedded in the plastic mass, or placed inside the body shell is another solution. Suitable choice of body form simplifies the mold form. The welding, finishing and painting operations can be eliminated.

External ribs in the plastic shell/body improve the grip and make for a lighter yet more rigid structure.

FILLER MATERIAL

The filler material of a hand grenade depends on the intended purpose of the grenade, which is usually one of the following:

1. High explosive.
2. Incendiary.
3. Smoke.

COMPOSITION B, DESENSITIZED

This material is: Stable in storage.
Suitable for loading in molten form.
Has reduced sensitivity to mechanical action.

Composition:	% by weight:
RDX (MIL-R-398)	60.0 ± 2.0
TNT (MIL-T-248)	39.5 ± 2.0
Wax (MIL-W-20553)	1.0 ± 0.3
Properties:	
Sand test brisance (compared to TNT = 100)	110
Explosive temperature test:	at 260° C decomposes in 5 seconds
Friction pendulum test: steel shoe	not affected
fiber shoe	
Heat test, % loss at 100° C:	0.05% in first 48 hours 0.19% in second 48 hours no explosion after 100 hours
Impact sensitivity (Bureau of Mines apparatus, 2 Kg weight), drop height:	95 cm
Rifle bullet test:	95% unaffected 5% burned
Initiation sensitivity: (minimum charge of LA to detonate sample)	0.22 gram
Vacuum stability (ml gas evolved), 120° C & 48 hrs.	0.99
Volatility:	0
Hygroscopicity at 30°C & 90% Relative Humidity:	0
Viscosity at 83° C:	3.5 poises
at 95° C:	2.6 poises

PREPARATION:

1. TNT is melted in a steam heated, jacketed kettle to a temperature of 95° C.
2. The molten TNT is stirred to maintain uniform temperature throughout the mix.
3. A water slurry of RDX is added slowly to the TNT.
4. After all RDX has been added, the heating and stirring of the kettle's contents is continued until most of the water is evaporated.
5. Wax mixture is added gradually and blended thoroughly into the mixture.
6. Final mixture is cooled to the desired fluidity for casting.

RDX, PHLEGMATIZED

One of the main advantages of RDX is the practically unlimited source of raw materials (coal, water, air). Its explosive and handling characteristics are even better than the "work-horse of high explosives", TNT. The major drawback of RDX is its inability to melt, hence it cannot be melt-loaded by itself and must be mixed with TNT. However, with the addition of a suitable desensitizing wax mix (in the original mixes beeswax was used) the explosive may be formed into pellets for ease of feeding and press-loading into the grenade.

Composition: (re: MIL-C-440)	% by weight
RDX (MIL-R-398), 95% retained on standard 100 mesh:	91.0 ± 0.7
Desensitizer wax mix:	9.0 ± 0.7
Foreign matter:	None
Moisture:	0.10 Maximum
Insolubles, retained on standard No. 40 sieve:	0
retained on standard No. 60 sieve:	5 Maximum
Acidity, %:	0.02 Maximum
Properties:	
Bulk density, gram/ml.:	0.85 Minimum
Physical consistency at 70-100° C:	Soft, self-binding under light hand pressure
Hygroscopicity:	None
Explosion temperature:	250° C
Sand test brisance (compared to TNT = 100):	108
Fragmentation effect: "	150
Ballistic pendulum test: "	132
Plate dent test: "	126
Vacuum stability (ml of gas evolved), 120° C & 48 hrs.:	Slightly more than TNT
Impact sensitivity:	Slightly less than TNT
Friction sensitivity:	id
Initiation sensitivity (minimum charge of LA to detonate sample):	Slightly more than TNT

PREPARATION:

1. Water slurry of RDX is heated in a jacketed steam kettle to 95° C.
2. The slurry is rapidly stirred by a mechanical stirrer.
3. Wax mixture containing a wetting agent is added gradually to the slurry.
4. After all wax has been added, the mixture is continued to be heated and stirred until most of the water has evaporated and the mixture is thoroughly blended.
5. Heating is stopped but stirring continues until the mixture temperature drops below the melting point of the wax.
6. Stirring is stopped and the mixture transferred to a filter.
7. Suction is applied to the filter to remove all vapors.
8. Material on filter is air dried at 75° C, tested and stored for further handling.

4. Gas.
5. Illuminating.
6. Blinding.

Hand grenades are generally not subjected to the high stresses experienced by artillery shells or rockets. The choice of a high explosive filler is therefore less critical. In the past, when the demand for artillery shells exceeded the HE supply, hand grenades were filled with a variety of "Ersatz" materials ranging from straight ammonium nitrate nitro-starches to fast burning smokeless powders.

Current high explosive grenade fillers are of 3 basic types:

1. Composition B, desensitized.
2. Phlegmatized RDX mixes.
3. PBX (plastic bond explosive) mixes.

Each of the above has certain advantages and disadvantages ovr the others, which must be considered during the selection. The research in this field is directed into developing more powerful fillers, allowing a smaller charge, safer and faster filling operation, and material stable not only under the traditional ambient conditions, but also under high electro-magnetic fields, radiation and very high temperatures.

Formulae and manufacturing processes for these three high explosives are given on pages 13 and 14 and below.

INCENDIARY GRENADE FILLERS

Incendiary grenade fillers are of 3 basic types:

1. White phosphorous — the most effective filler not only as an incendiary, but also in anti-personnel applications. WP casualties usually require more treatment than fragmentation-inflicted ones. However, WP is difficult to get, transport and handle. It is very toxic and hazardous to handle without special equipment and training. Therefore, when used in an expedient grenade this material is as dangerous to the manufacturer as it is to the intended target and should thus be avoided.
2. Thermites — These mixes of aluminum and magnesium powder fuels and iron oxide oxidizers are most effective against metal targets. Thermites require a strong igniter and delay mixes for positive ignition. They

PBX (PLASTIC BONDED EXPLOSIVE)

Another RDX mix which is suitable for grenade filling is the PBX. Although intended primarily for rocket grain extrusion, this mix is adaptable for filling grenades with semi-liquid filler which cures and solidifies in place.

The PBX composition is usually 90% RDX with 10% plasticizer. The plasticizer must be both chemically and physically compatible with RDX. Typical compositions are shown below:

Composition Designation:	PB-RDX	PVA-4
RDX	90%	90%
Polystyerene, unmodified	8.5%	
Dioctylphtalate	1.5%	
Polyvinyl acetate		8%
Dibutylphtalate		2%
Intended use	High mechanical strength explosive	Demolition charge

The manufacturing process for PBX is very similar to that of wax coated RDX mixes.

THERMITE

A standard incendiary mix similar to thermate in performance, but slightly different in its composition.

MATERIAL	SPECIFICATION	% BY WEIGHT	REMARKS
Aluminum, atomized	MIL-A-512	21.5 ± 0.5	Grade III
Aluminum, granular	MIL-A-512	2.8 ± 0.03	Grade II
Aluminum, flaked	MIL-A-512	1.0 ± 0.01	Grade I
Iron oxide, black, technical, Fe_3O_4	MIL-I-275	58.5 ± 0.5	Class B
Barium nitrate	MIL-B-162	15.0 ± 0.15	Class 5
Sulfur	MIL-S-487	0.9 ± 0.01	Grade E
Castor Oil	MIL-C-15179	0.3 ± 0.003	

FIRST FIRE MIX

MATERIAL	SPECIFICATION	% BY WEIGHT	REMARKS
Silicon	MIL-S-230	25	
Red lead	TT-R-191	50	
Titanium	MIL-T-13405	25	Type I
NC/Camphor	MIL-B-10854	1.8 Maximum	10% solution in acetone (O-A-51)
Graphite	MIL-G-155	0.6 Maximum	

Note:

DELAY MIX V

MATERIAL	SPECIFICATION	% BY WEIGHT	REMARKS
Silicon	MIL-S-230	20.0 2.0	
Red lead	TT-R-191	80.0 2.0	Type I
Diatomaceous earth	MIL-D-20550	5.0 2.0	To adjust burning time, grade A
NC/Camphor	MIL-B-10854	1.8	Binder, used in 10% solution in acetone (O-A-51)
Graphite	MIL-G-155	0.6	

IGNITION MIX III

MATERIAL	SPECIFICATION	% BY WEIGHT	REMARKS
Zirconium	JAN-Z-399	17.5	
Titanium	MIL-T-13405	32.5	95% — 200 mesh
Iron oxide, red, Fe_2O_3	TT-P-375	50.0	

THERMATE
A standard incendiary mix.

MATERIAL	SPECIFICATION	% BY WEIGHT		REMARKS
Aluminum, grained	MIL-A-512	16	19	Grade II
Aluminum, flaked	MIL-A-512	9	3	Grade I
Iron oxide, black, technical, F_3O_4	MIL-I-275	44	51	Class B, 12 mesh
Barium nitrate	MIL-B-162	29	22	Class 5
Sulfur	MIL-S-487	2.00		Grade E
Resin*	MIL-R-7575		5	

* Commercial LAMINAC 4116 plus catalyst

CHARACTERISTICS:
1. Material burns with intense heat (approximately 2200° C), melting most metals. It cannot be extinguished with water or chemicals, the burning is constrained by sand or earth.
2. Burning material does not produce any physiological action except severe burns which are treated as thermal burns.

STORAGE: Material is stable when stored in metal containers; although a fire hazard, there is little danger of material catching fire unless it is stored with an igniter. It is not susceptible to spontaneous heating.

SHIPPING: DOT classification — flammable solid.

DECONTAMINATION: None required; empty containers are rinsed with water.

PROTECTION: None required except in fighting fire.

NOTE: Chemical fire extinguishers containing carbon tetrachloride or liberating carbon dioxide should not be used to extinguish thermate fires in closed spaces. Carbon tetrachloride in contact with hot metal particles produces a mixture of phosgene, chlorine, carbon monoxide and hydrochloric acid. The standard field protective mask does not protect against carbon monoxide.

are relatively safe to handle and assemble but the proper materials are not always available.

3. Napalm — the name is a common term used for gelled gasoline incendiary mixtures. Its primary use is to ignite and/or burn materiel and buildings, but it also acts as an effective casualty producing agent. Napalm casualties are caused primarily by the heat of the combustion. The stickiness of the mix, prolonged burning and the high flame temperature cause deep, third degree burns.

The secondary effect of napalm is the generation of carbon monoxide which, especially in closed areas, has a pronounced toxic effect.

Due to the limited volume of a conventional grenade body, the effect of napalm filler is severely reduced. Yet napalm is presently used for expedient type grenades by various irregular forces.*

THERMITE

These mixes are usually loaded into the grenade body in the following manner:

a. One half of the thermite main charge is placed into the body cavity and consolidated with a minimum dead load of 8½ tons.
b. A second half of the thermite charge is placed over the consolidated first half and is also consolidated with a minimum dead load of 8½ tons. The consolidating punch

* *Another filler which has a secondary incendiary effect is the illuminating mixture described later in the text.*

should have a face contour shaped like the final form of the incendiary filler.

c. A charge of 40 ± 3 grams of first fire mixture VII (thermite igniter) is placed over the consolidated thermite charge and also compressed with the same force and the same tool as the second thermite increment.
d. All personnel are to be protected during the filling and consolidating operations.

ILLUMINATING GRENADE FILLER

The illuminating mixes consist of:

1. Metallic fuel, finely pulverized, usually aluminum or magnesium or alloys thereof.
2. Oxidizer, usually $NaNO_3$.
3. Binder, formerly paraffin; presently gradually being replaced by synthetic resins with polymerization agents and catalysts.

General characteristics of mixes:

1. Sensitive to impact, friction, flame, spark and static electricity.
2. Hazardous, containing large potential energy which may be released with destructive violence.

Basic handling procedures:

1. Personnel safety procedures must be the same as when handling primary high explosives used in priming mixes.
2. Process in relatively small batches, behind 1/2" or thicker laminated safety glass.
3. All operations must be remotely controlled.
4. All equipment must be grounded.
5. All equipment and tools to be of non-sparking materials.
6. Mortar and pestle or other means of mixing which can subject the materials to friction or impact must not be used.
7. All mixing to be done by non-friction method only (jelly-bean bags).
8. Premix fuel and binder before adding oxidizer.
9. Thorough knowledge of binder characteristics and dangers of chemical, toxicological and explosive nature are required; the reactions and timing of accelerator additions must be known.
10. Flammable solvents must not be added to the illuminating composition for improved blending (adding acetone to binders, for example, increases explosion hazards).

Loading and assembly procedures:

1. Composition weighing to be done behind a barricade, well away from the loading area.
2. Individual compositions are separated from each other by baffles.
3. Molding and/or loading equipment and tools to be from non-sparking materials only.
4. Equipment and operations to be remotely controlled.
5. Equipment and tools to be clean, free from foreign materials.
6. Equipment and tools to be periodically inspected for burrs, defects and correct alignment.
7. Working area, equipment and tools to be periodically swept with static-proof brushes.
8. Finished products to be removed continuously and immediately to storage, away from work areas.

FUZE

Fuze is the most complex element of any high explosive projectile, hand grenades included.

The factors which enter into consideration of a hand grenade fuze design are:

1. Reliability — the fuze must function under all expected conditions.
2. Safety — in storage, handling and use.
3. Simplicity — fuze must be structurally simple for easy manufacture and quality control.
4. Non-strategic materials — materials must be readily available, from a variety of sources; materials must not be critical in quality.
5. Inexpensive — cost of the finished fuze to be as low as possible.
6. Stable — all components in the assembled fuze should have a long shelf life under a variety of ambient conditions; fuze must be rust proof.

Some of the above factors are diametrically opposed in nature to each other. The simplest, and least expensive fuze is a piece of safety fuze and a cigarette match. However, it is neither the safest nor the most reliable one.

Although a delay element is a relatively inexpensive, simple means of increasing the user's safety, some sources prefer the impact-instantaneous fuze, believing it to be both safer and better.

CLASSIFICATION OF HAND GRENADE FUZE

A. DELAY

ADVANTAGES:
1. Tested, reliable system.
2. A 4-5 second delay allows grenade to travel for a safe distance from user.
3. If accidentally dropped, delay still allows the grenade to be picked up and thrown.

DISADVANTAGES:
1. Correct delay timing required: a short delay makes the grenade dangerous to handle, long delay allows the target to move away from impact area or throw grenade back.
2. Thrown uphill, the grenade may roll back and explode near user.

Striker spring actuated (AA) | Pull friction (AB) | Match head (AC) | Percussion manually actuated (AD)

B. IMPACT

ADVANTAGES:
1. No time at target for grenade pickup and throw-back.
2. No time at target to take cover.
3. Includes a self-destruct element.
4. Instant action.

DISADVANTAGES:
1. Solid impact surface required.
2. Critical to balance sensitivity for action in snow, mud, etc., against insensitivity when going through brush and light cover.
3. High malfunction rate when impacting on soft surface.
4. Relatively complex mechanically.
5. Unsuitable for manufacture by expedient methods.

Mechanical oriented (BA) | Mechanical all ways (BB) | Electrical (BC)

The final choice of a fuze system is a judicious compromise of all the above factors which is most acceptable to the client.

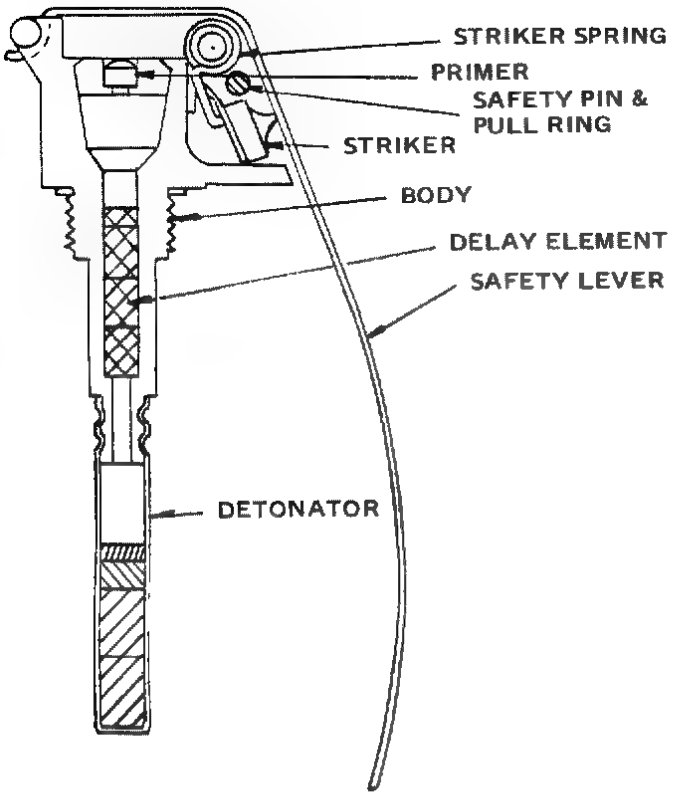
General Considerations

A hand grenade is a projectile thrown by physical force of the user. In comparison to other projectiles it has the following characteristics:

1. Unstable trajectory.
2. Unpredictable fuze orientation in respect to the target (exception as an AT grenade with impact type, mechanical, oriented fuze).
3. Uniform forces used in arming of artillery fuzes are absent.
4. Forces exerted on hand grenade fuze during throwing are equal and/or similar to those present during shipping and handling.
5. Delay timing at 4 + 1 seconds is generally adequate for service use.
6. The fuze explosive train consists of:
   Primer (or match)
   Delay
   Detonator (blasting cap)
7. The energy actuating a fuze primer varies, depending on:
   a. Type of primer
   b. Type of primer seat
   c. Striker form and weight.

   An energy of 30" oz. (1 oz. weight dropped 30") will fire all percussion primers in current use.
8. Detonator safety — although not in general use, this would be a desirable feature of a hand grenade fuze.
9. The delay mix housing should be sufficiently strong to withstand the forces required for delay mix compacting, yet light enough to remove heat generated during delay burning. The less heat-absorbent the housing, the smaller the diameter of the delay column required (provided all other parameters remain unchanged) to propagate positively the primer flame to the detonator.
10. The smaller and lighter the fuze, the lighter and more compact will be the grenade, for a given charge and housing of the grenade.

EXPEDIENT HAND GRENADES

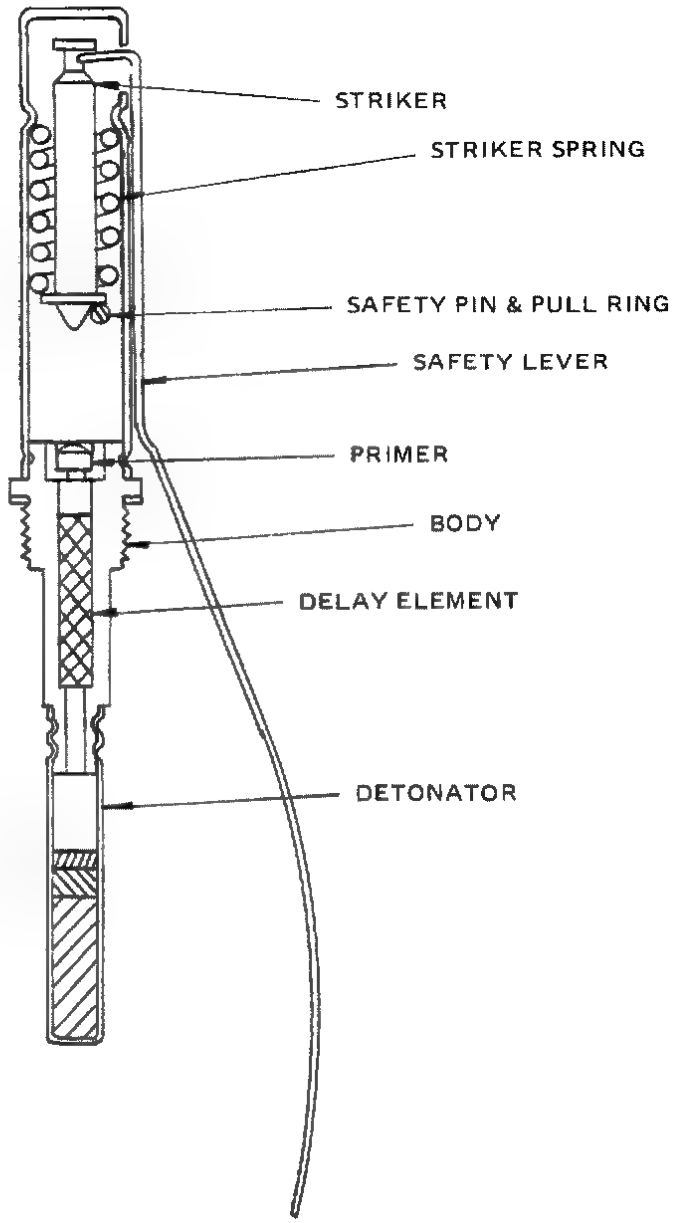


OPERATION:
1. Holding the grenade body and the fuze safety lever firmly, pull the safety pin out.
2. Throwing the grenade releases the safety lever and clears the path for the striker.
3. The striker spring forces the striker against the primer and initiates the explosive train.

ADVANTAGES:
1. Simple operation.
2. Simple and reliable system.

DISADVANTAGES:
1. After safety pin removal, the fuze becomes armed if dropped accidentally.

NOTE: This fuzing system is the most common type used throughout the world. Although it is gradually being supplanted by the impact type fuzes, it will remain in service for years to come.

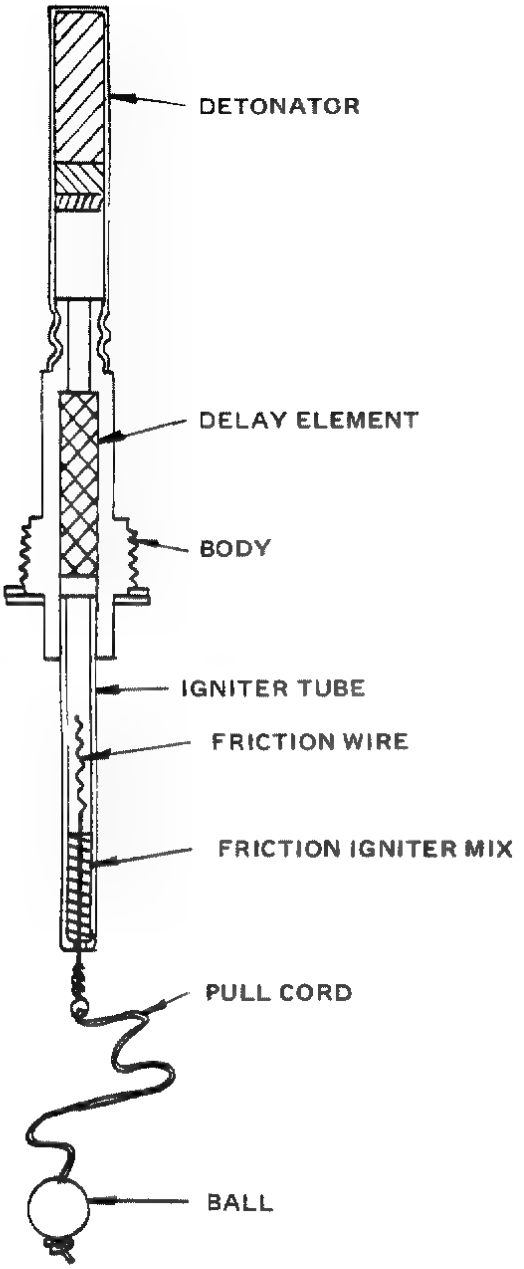


ADVANTAGES:
1. Simple operation.
2. Simple and reliable system.
3. Use of coil spring and screw machine-made striker simplifies manufacture.

DISADVANTAGES:
1. After safety pin removal, fuze becomes armed if dropped.
2. Safety lever pivot angle is shorter than other types, thus reducing arming time.
3. Fuze sticks further out of grenade than other types.

TYPE AA

Two different fuze delay hand grenades with spring actuated strikers are illustrated above. Although they represent the most common fuzing system throughout the world, they are gradually being replaced by impact type fuzes. However, they will still be in service for some time to come.



OPERATION:
1. Pull cord rapidly out; the wire coated with abrasive compound will rub against the match head mix which ignites.
2. Throw the grenade at the target.

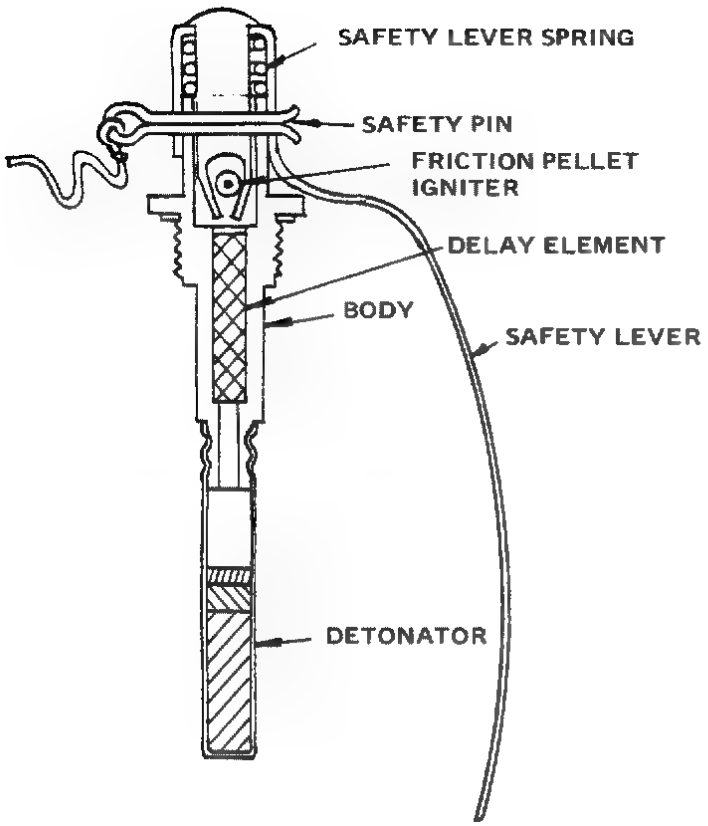
NOTE:
1. This is the second most common type after the striker/spring actuated.
2. This fuze system was used in the German Army grenade No. 24 throughout two World Wars quite effectively.
3. Although commonly associated with grenades equipped with a hollow throwing stick handle (acting as protection for the igniter assembly) this fuze type is adaptable to any grenade type.
4. For shorter over-all fuze length the friction wire should be located and pulled perdendicularly to the detonator axis.

ADVANTAGES:
1. Simple and reliable system.
2. Does not require a primer.

DISADVANTAGES:
1. Fuze is armed while the grenade is still in user's hand, reducing safety.
2. Additional operations required for arming.
3. Provision to protect the friction igniter assembly is required.

TYPE AB

Pull Friction Actuated Fuze Delay Hand Grenade.



TYPE AC

Match Head Compound Actuated Fuze Delay Hand Grenade

OPERATION:

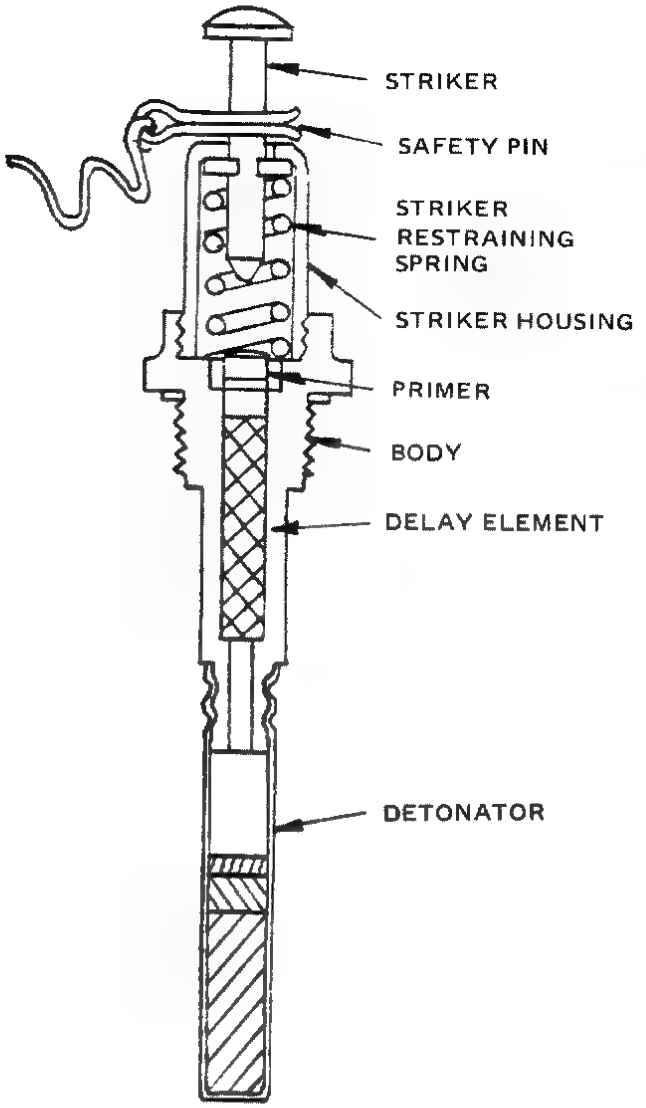
1. Holding the grenade body and the fuze safety lever firmly, pull the safety pin out.
2. Throwing the grenade releases the safety lever.
3. The lever spring pulls the scratch surface against the igniter pellet thus initiating the explosive train.

ADVANTAGES:

1. Simple operation.
2. Simple and reliable system.
3. Primer is not required.

DISADVANTAGES:

1. After safety pin removal the fuze becomes armed if dropped accidentally.



TYPE AD

Manually Actuated Percussion Fuze Delay Hand Grenade

OPERATION:

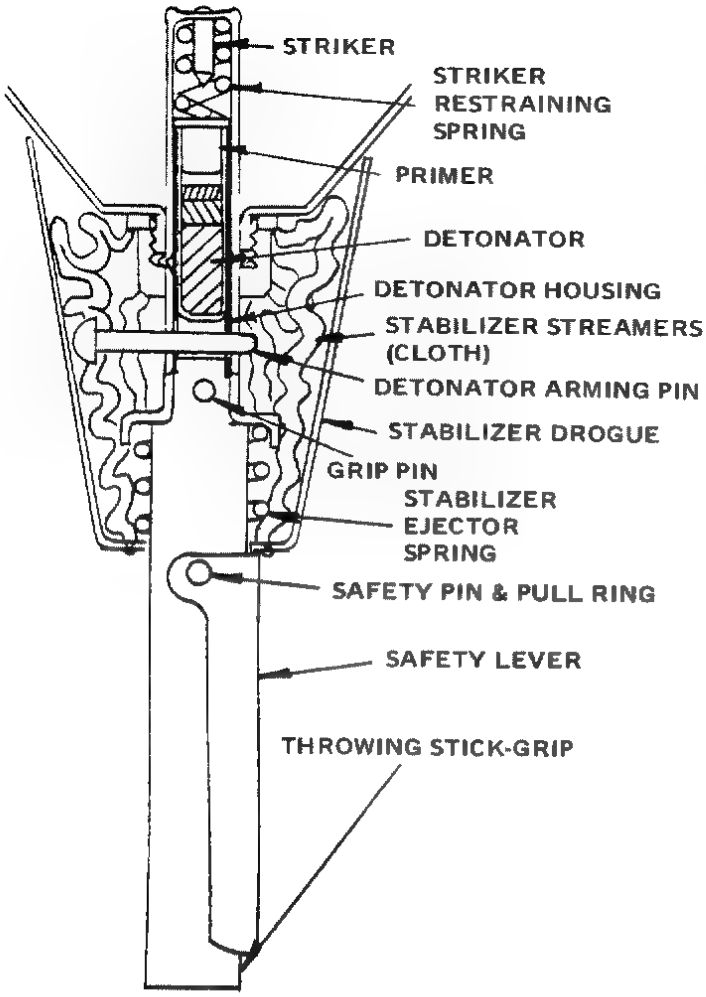
1. Pull safety pin out.
2. Hit striker sharply against a hard surface (stone, rifle buttstock, shoe heel, etc.); the striker is driven against and fires the primer.
3. Throw the grenade at the target immediately.

ADVANTAGES:

1. Simple and reliable system.
2. Hard surface needed to fire the fuze.
3. Additional operation required for fuze arming.

NOTE: This type fuze is inferior to all other delay type fuzes.

EXPEDIENT HAND GRENADES



TYPE BA

Inertia Oriented Striker Fuze Delay Hand Grenade

OPERATION:

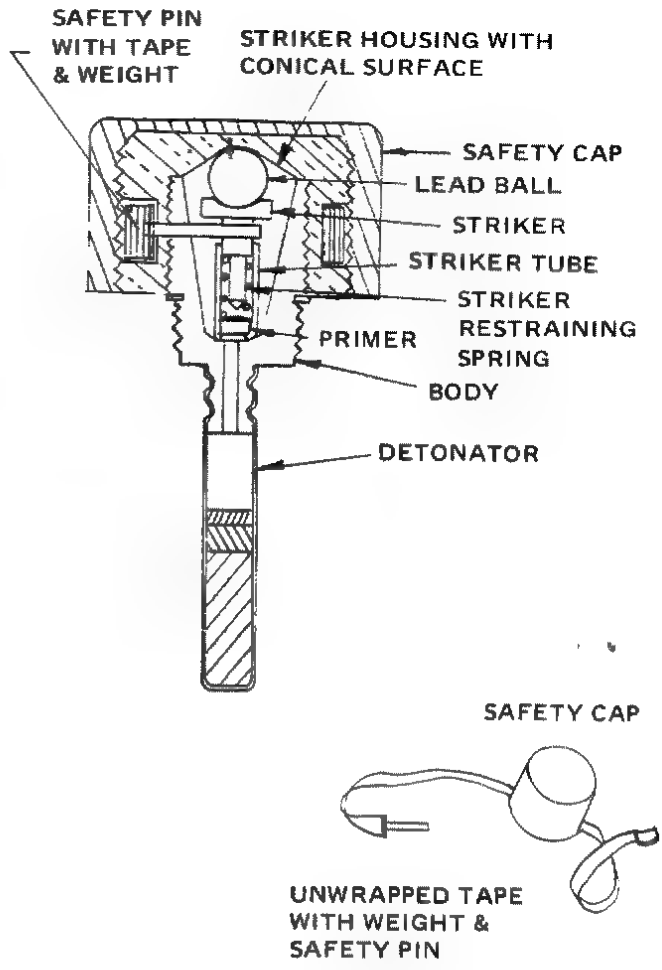
1. After safety pin removal and after leaving the thrower's hand the safety lever is ejected from the fuze by the force of the stabilizer ejector spring.
2. The removal of the safety lever allows the stabilizer drogue to slide off the stick-grip, thus pulling out the stabilizing streamers.
3. The pull-out of the streamers and the drogue displacement allow the detonator arming pin to drop out and to free the detonator housing.
4. Upon impact of the grenade, the detonator assembly moves under inertia, compresses the striker restraining spring and drives the primer against the striker.

ADVANTAGES:

1. Location in the projectile base allows use of shaped charges.
2. Does not require a delay system.

DISADVANTAGES:

1. Must be oriented for proper functioning.
2. Needs hard impact surface for positive ignition.



TYPE BB

All Ways Impact Striker Fuze Hand Grenade

OPERATION:

1. After the safety cap has been unscrewed and the grenade thrown, the weight unwraps the tape and pulls the safety pin out, thus the fuze is armed after leaving the hand, away from the user.
2. Upon impact the lead ball moves along the conical surface of the striker housing, forcing the striker against the primer.
3. The primer ignition starts the explosive train.

ADVANTAGES:

1. Fuze is armed only after leaving the user's hand and unwrapping of the tape; this gives about 2 seconds' arming time.
2. Accidental dropping of the grenade does not arm the fuze.

DISADVANTAGES:

1. Use of this fuze in close brush may tangle up the tape and affect the arming.
2. Unscrewing of the safety cap is more complex and time consuming than pulling the ring, especially with a gloved hand.
3. Fuze assembly is more complex than other fuzes.

TYPE BC

Electric Impact Fuze Hand Grenade

This type fuze contains an electric energy source plus an electrical delay detonator. The fuze is activated either during throwing action or upon impact, depending on the design.

A typical example of such fuze is the US Army M217 fuze, resembling externally the M213 striker, delay fuze. The M217 fuze has a small thermal battery, activated upon throwing by a striker.

The battery activation time of 1.5 seconds plus the fuze arming time of 0.5 seconds give a total arming time of 2.0 seconds. This provides safety for the user.

Upon impact the fuze acts as an "all ways" type. A ball, located between two tremble switches (located at 90° to each other) closes the circuit, firing the detonator.

This fuze is also provided with a self-destruct switch activated in 4.5 seconds.

ADVANTAGES:
1. **Design incorporates the best features of a fuze, arming only after leaving the user's hand.**
2. **All ways type.**
3. **No mechanical delay.**
4. **Self-destruct mechanism.**

DISADVANTAGES:
1. **Relatively complex.**
2. **May be subject to radio frequency and electromagnetic action under proper conditions.**

NOTE: The M217 fuze was used in the Vietnam War but has since been withdrawn from servive.

Fuze Components

A typical hand grenade fuze consists of the following sub-assemblies:

1. *Housing* — the fuze body holding and consolidating all other fuze components; it is usually screwed into the grenade body during final grenade assembly.
2. *Primary safety* — an element which must be removed manually before the fuze can function; there are two basic types:
   a. Cap — must be unscrewed — is used on throwing stick grenades and some grenades designed and used by the smaller European countries.
   b. Cotter pin & pull ring — must be pulled out — simplest, fastest, most universal method.
3. *Arming safety* — This component is removed in flight, after the grenade leaves the thrower's hand. Some friction, pull type fuzes do not have this safety and are thus armed while still in the hand. Again, there are two basic types of arming safety:
   a. Safety lever — held by the same hand as the grenade body.
   b. Weighted tape & pin — the tape must unwrap and pull the pin for arming.
4. *Firing device* — impact actuated mechanism whereby heat, stored spring energy, electrical current, etc., is released to fire the primer.
5. *Primer* — this is the starting element of the explosive train; there are four types:
   a. Match — a plain match head ignited manually is the simplest and probably oldest fuze component.
   b. Friction— a sensitive chemical mix ignited by rubbing against a rough surface.
   c. Small arms primer — actuated by a spring-driven pin, the most common primer used today.
   d. Chemical — breaking of an ampule creates an exothermic reaction or generates electric current.
6. *Delay element* — a powder train with controlled burning rate to create a time interval between the initiation of the primer and the explosion of the detonator; this fuze element is absent in the impact/instantaneous type fuzes.
7. *Detonator* — this component is an amplifier of energy; the primer flame ignites a small charge of sensitive explosive (Lead Azide) which in turn sets off a pellet of less sensitive high explosive (PETN or RDX). Usually the detonator is a non-electric blasting cap powerful enough to set off the grenade HE filler or act as the scattering charge in a smoke or gas grenade.

Historically, not every fuze type contained all the elements listed. The earlier models were usually lacking the safety and arming, or delay elements. However, modern fuzes do conform to the above pattern.

The fuze housing is a component consolidating and assembling all the fuze components. The housing is usually screwed directly into the grenade body.

Most housings are made from:

1. Zinc die casting, as the least expensive mass-produced item; examples are the US fuzes.
2. Stampings and/or screw machine stock,

allowing design of tubular elements and use of plain coil springs; examples are the Soviet fuzes.

3. Metal and plastic assemblies, allowing safer final assembly of the fuze elements, but probably slightly more expensive than the above methods; examples are the latest German fuzes.

The future of this component lies in the use of high impact strength plastic which will allow:

a. Lighter construction.
b. Eliminate surface finishing and/or painting.
c. Allow use of improved design safety lever.

DELAY ELEMENT

The most important element of a grenade, from a safety point of view, is the delay element. While a defective grenade filler, fuze detonator or primer may cause a grenade malfunction (called a "dud"), a defective or absent delay element will inflict casualties on the user and all those around him.

The fuze housing safety lever, safety pin, etc., although very important, can be inspected visually for defects. The delay powder column, on the other hand, may appear to be in place and full, yet have an internal fault which will cause a "blow-through" and detonate the grenade prematurely. The assembly and inspection of delay elements in the fuze housing and all subsequent operations on the fuze assembly require repetitive, 100% inspection, both visual and X-Ray.

It is for these reasons that some designers and manufacturers design and make fuzes without delay elements, or with systems which arm the grenade far away from the user. Some fuzes of the most modern type try to protect the user by incorporating additional safety elements between the delay and detonator.

The delay element burning time is affected by:

1. Type of mix.
2. Column diameter.
3. Column height.
4. Compacting pressure.
5. Envelope material.
6. Envelope shape and thickness (both act as heat sink).
7. Envelope geometry (possible venting).

Of the above factors, the delay column and the envelope geometry are usually specified by the material of the fuze body and by the grenade body geometry. Hence, only the delay mix composition and compacting force may be varied to obtain the desired results.

The present day delay element material is zirconium-nickel composition specified MIL-C-13739A, type [redacted]. The quality and uniformity of this material is closely controlled. One of the world's largest and best manufacturers of this mix is Pyrotechnic Specialties, Inc., of Byron, Georgia. They supply a pelletized delay mix which exceeds military specifications in quality and performance.

DETONATOR

In World War II hand grenade fuze detonators were mostly non-electric blasting caps in as-is or slightly modifed characteristics. A classic example of a detonator of this type is the C58 used in the M204 and M206 fuze. These detonators were made from components and on machinery used for the production of commercial blasting caps. For wartime expediency, this approach assured an [redacted] and reliable supply when needed.

As the shape of the new grenade bodies changed, the fuze detonators had to be modified to fit into these grenades.

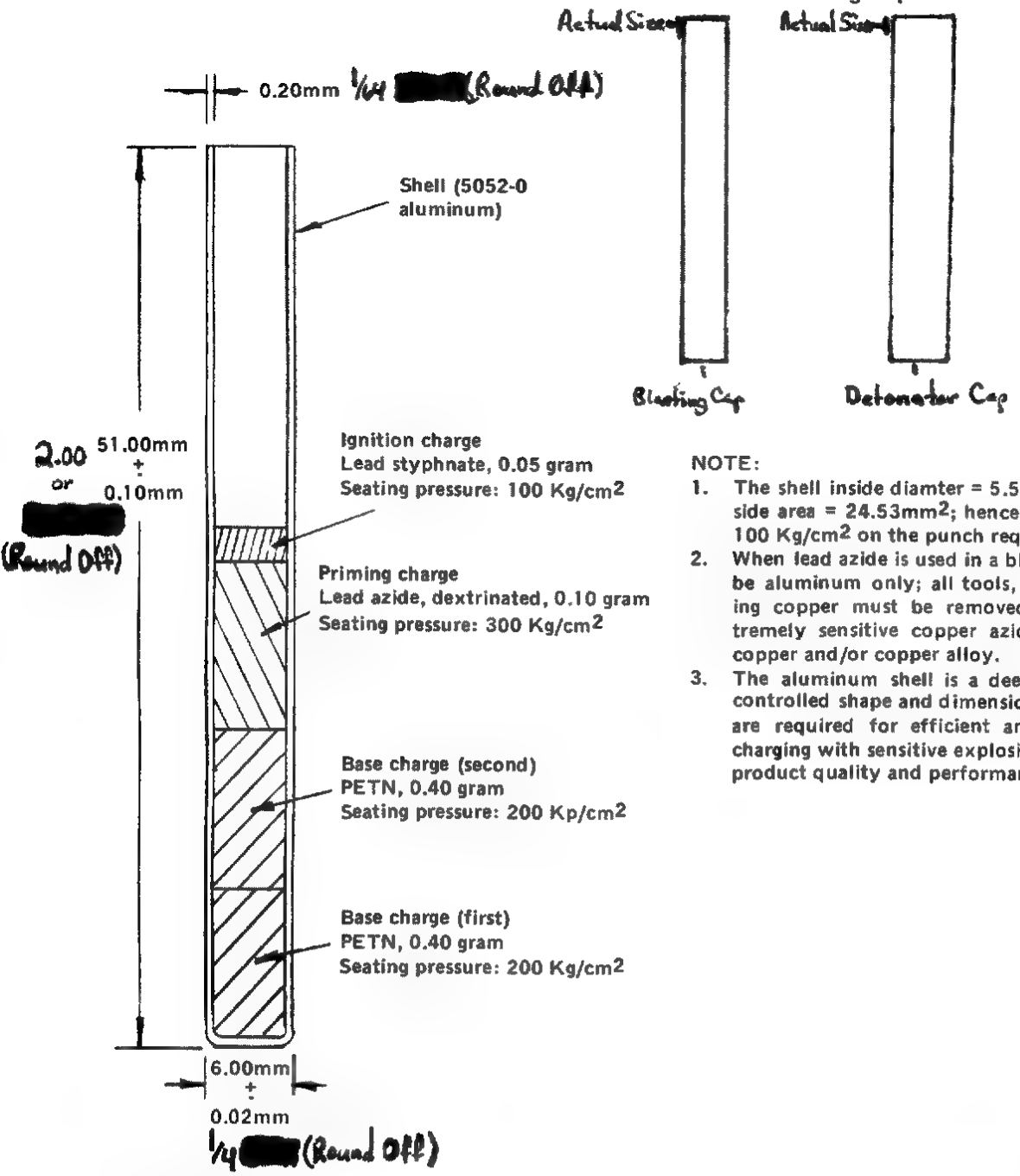
Assembling a detonator is the most dangerous single operation in grenade manufacture. The filler materials are sensitive by nature and the quantities are relatively large, as compared to the primer, by requirement. The forces needed to consolidate the detonator filler are also significant.

These factors must be considered when designing a new detonator and it is this reason why most successful detonators are commercial blasting caps of proven design.

BLASTING CAP NOTES:

1. Blasting caps were not needed when black powder was the only explosive used; a black powder charge can be exploded reliably with flame or spark only.
2. Blasting caps are needed to detonate the modern high explosives, whether [redacted]tly or through a booster.
3. Early blasting caps were graded by the weight of mercury fulminate in the cap. A charge of 1 gram mercury fulminate will reliably detonate a charge of nitroglycerin dynamite. This size blasting cap has been designated as No. 6. The No. 1 blasting cap contains 0.3 gram mercury fulminate.
4. Blasting caps of current manufacture may contain a charge of PETN or RDX which will produce the same or more power than 1 gram mercury fulminate. The actual charge weight in

No. 8 Non-Electric Commercial Blasting Cap



NOTE:

1. The shell inside diamter = 5.59 — 0.02mm; the shell inside area = 24.53mm^2; hence to produce a pressure of 100 Kg/cm^2 on the punch requires a weight of 25 Kg.
2. When lead azide is used in a blasting cap, the shell must be aluminum only; all tools, containers, etc., containing copper must be removed. Lead azide forms extremely sensitive copper azide when in contact with copper and/or copper alloy.
3. The aluminum shell is a deep extrusion with closely controlled shape and dimensions; these close tolerances are required for efficient and safe mass production charging with sensitive explosives as well as for uniform product quality and performance.

the cap depends on the type of explosive used and may actually be less than 1 gram.

5. The No. 8 blasting cap is more powerful than the No. 6 and is generally used for military applications. It originally contained 2 grams of mercury fulminate.
6. In the late 1950's a series of various caps, squibbs, bolt cutters, etc., appeared for use in the aerospace industry and for various specific military uses. These special purpose items are not covered in this book.
7. Until recently, electric blasting caps were preferred due to reliability, ease of installation and safety. However, the rapid increase in the use of CB radios and other electric energy generating devices created extra hazards requiring careful shunting of wires, etc.
8. Non-electric caps require good quality safety fuze. The recent development of reliable and simple delays increased the use of non-electric blasting caps.

Expedient Fragmentation Grenade

A good expedient hand grenade must follow the same rules of safety, reliability and performance as its military or commercial counterpart. Furthermore, it must fulfill these conditions:

I. All materials to be readily available locally from sources which are not controlled and/or monitored by occupation authorities.

Grenade assembly is done with tools readily available and used in everyday life; such tools must be easy to procure and/or make.

II. Manufacturing procedures and techniques must be SAFE, simple, easy to learn and to teach.

III. Grenade must be easy to use with a minimum of training required.

Any container (box, bottle, can, etc.) can act as a grenade body. However, some are more suitable than others. Straight cylindical (tubular) bodies opened at both ends are preferred because they allow safer loading and compacting of the filler material.

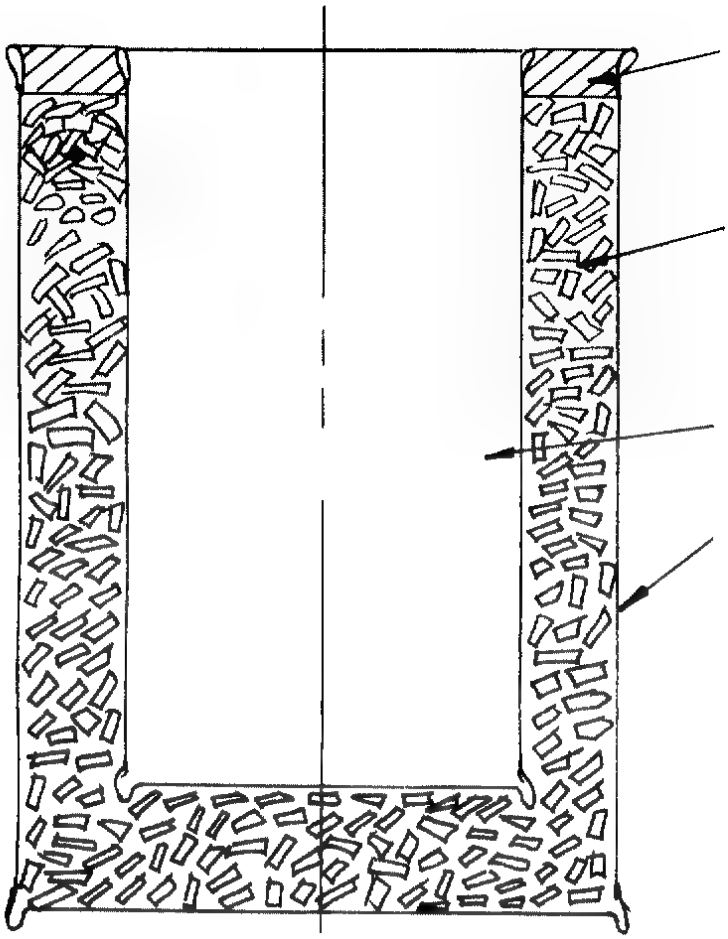
Following is a brief list of some materials and their suitability. Although incomplete, this list shows what factors to consider when selecting the necessary material:

MATERIAL:	CHARACTERISTICS:
Iron water pipe, 1½"-2" dia.	Requires pre-notching for optimum fragment pattern. Nipples & end caps are expensive. May require lacquering or coating inside for compatibility with filler. Assembled with threaded end caps performs well even with low power filler. Requires pipe cutting & threading tools.
CO_2 cartridge	Very small capacity. Difficult to fill properly & safely. Difficult to attach any but safety fuze. Poor fragmentation pattern.
6 oz. juice can	Readily available. Inexpensive (drink contents). Optimum size. Adaptable to a variety of fragmentation sleeves*. Easy to fill due to cylindrical form.
Cardboard tube (container for maps, etc.)	Readily available. Available in various sizes.

**To make a fragmentation sleeve:*

1. *Unravel a heavy wire coathanger into a straight piece of wire.*
2. *Put one end of the wire into the hole in the mandrel.*
3. *Wind the wire into a tight coil over the mandrel.*
4. *With a hacksaw or cold steel chisel, notch the wire into 1/4" segments about halfway through the wire thickness.*
5. *Slide the notched sleeve over the grenade body.*
6. *Secure fragmentation sleeve to the body with glue and/or tape at the ends of the coil.*

EXPEDIENT FRAGMENTATION HAND GRENADE BODY



PROCEDURE:

a. Fill bottom of large can with about 3/8" layer of cuttings.
b. Position small can centrally over the bottom layer.
c. Fill all space between cans with cuttings.
d. Apply epoxy adhesive as shown and let it dry for 24 hours.

NOTE: Do not damage the inside can during assembly; be sure that it remains clean and smooth on the inside.

This is the optimum choice of shape and size:

1. Components are inexpensive and readily available.
2. The filler is protected and constrained for maximum efficiency.
3. The manufacture is simple, not requiring special tools.
4. The fragmentation pattern is very good.

Adaptable to a variety of fragmentation sleeves. Easy to fill due to cylindrical form. Easy to cut & close. Must be waterproofed for protection. Will not accept liquid filler without special lining.	35mm film container	Expensive if more than a few are required. Small capacity requires a powerful high explosive filler. Requires fragmentation sleeve. Compact & inconspucuous. Good choice for use in a confined area or vehicle.

COMPARISON CHART OF BURNING SYSTEMS

	FIREPLACE	RIFLE CARTRIDGE	30mm CARTRIDGE	HAND GRENADE	"EXPLOSIVE CHARGE"
PHYSICAL START	Strike match	Firing pin spring	Electric current	Striker spring	Electric current
PRIMING	Match head	Merc. fulm. or LS/Tetr. mix	Bridge-wire LS/Tetr. mix	Merc. fulm. or LS/Tetr. mix	LS or lead azide
1st BOOSTER	Wood shavings	None	Black powder	PETN	PETN
2nd BOOSTER	Small twigs	None	None	PETN	PETN
MAIN CHARGE	Split logs	Smokeless powder	Smokeless powder	RDX-TNT mix (comp. B)	TNT or RDX or AN mix

EXPEDIENT EXPLOSIVE FILLER

The explosive grenade filler is expected to produce a large number of high velocity fragments with the best casualty-inflicting potential.

Before getting into the details of these materials it is appropriate to have a brief discussion of explosion. Explosives are materials with a relatively high speed of burning and/or decomposition rate. It is this high speed of energy liberation which causes the "explosion". A comparison between various "burning" systems appears above.

In general:

1. The higher the detonation velocity of the filler material, the smaller the fragments in size, the more uniform in shape and weight and the higher their velocity.
2. The higher the detonation velocity of the filler material, the higher velocity must be the fuze material to give positive ignition to the filler.
3. Fuze must be placed in the middle of the filler as shown on the drawings to assure maximum energy transfer from the fuze to the filler, again for positive ignition.
4. Most fillers are friction sensitive to some degree, hence should be protected from direct contact with the metal surface of the grenade body.
5. Black powder, match heads, flash powder and sugar/chlorate mixes are very easily ignited, hence require extra care in handling.

Since the materials used as fillers in military grenades are not readily available to the general population, the expedient grenades may be filled with a variety of substitutes listed below:

A. Black Powder — readily available, relatively safe, stable in storage, hygroscopic, low power, requires fuze of open flame or intermediate igniter.

B. Smokeless Powder — readily available, stable in storage, relatively safe, more difficult to ignite than black powder, requires a stronger grenade body (to build up pressure) than black powder for maximum effect, requires fuze of open flame or an intermediate igniter. Shotshell and/or pistol powders give better performance than rifle powders. When used in a pipe body a rifle powder will generally split the pipe; a pistol powder will break it into large fragments but a double base shotshell or pistol powder in a pipe body with a blasting cap fuze will detonate like a HE and produce a large number of high velocity fragments.

C. Match Heads — readily available, easy to ignite, stable in storage, MOST SENSITIVE TO FRICTION, requires a strong grenade body for optimum performance.

D. Flash Powder Mix — generally used in firecrackers, military simulators, etc.. easily ignitable, stable in storage, sensitive to friction. Typical flash powder formulae:

MATERIAL	PARTS (by weight)				
Potassium chlorate	2	3	6	7	8
Aluminum powder, fine	1	4	1	1	2
Sulfur powder, fine	1	3	1	2	1
Antimony sulfide				1	

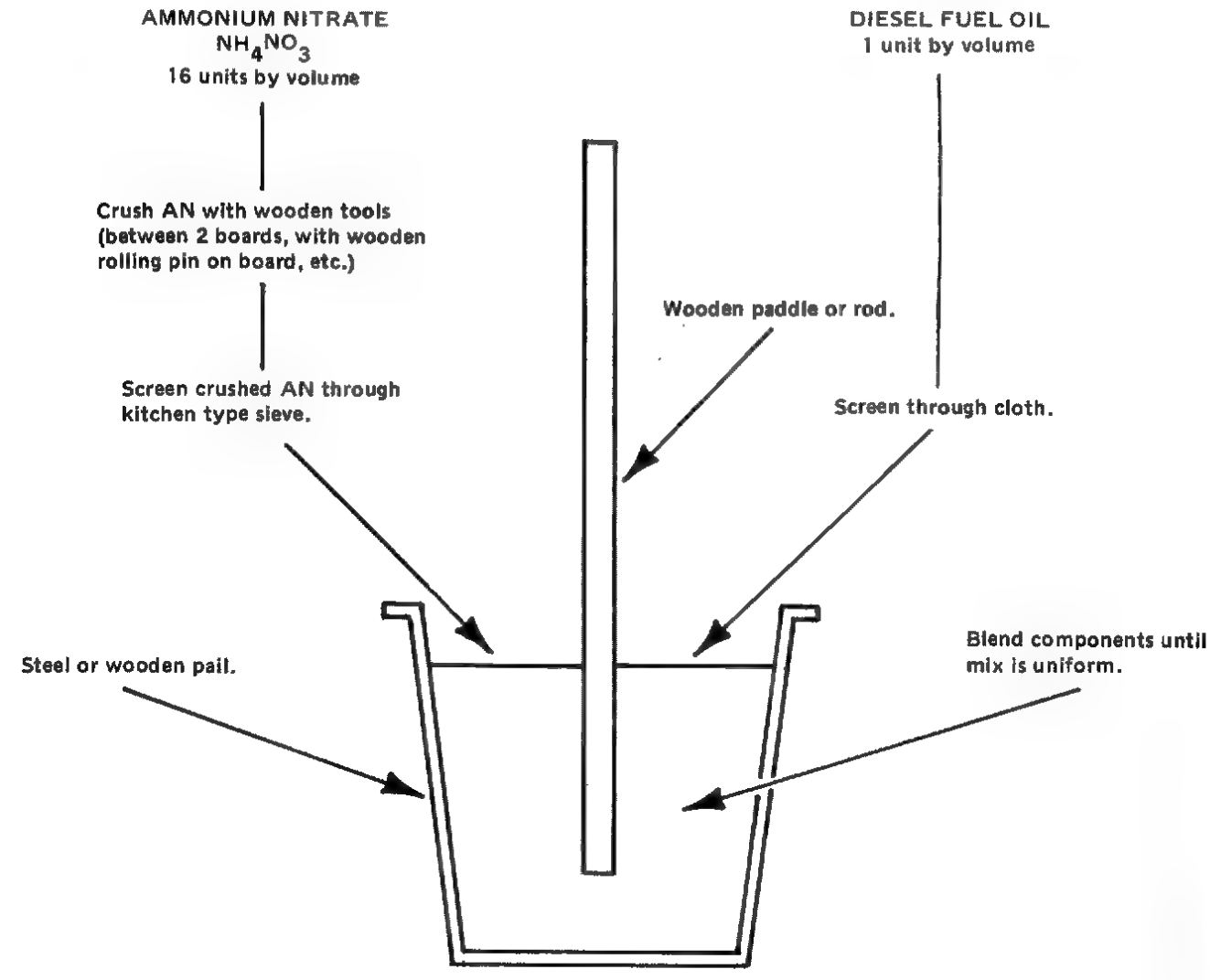
E. Sugar/Chlorate Mix — a mix which is not only incendiary, but also explosive, if properly ignited and constrained; a 40/60 mix of sugar/chlorate may be comparable to 40% dynamite. Potassium chlorate mixes are used in Europe as a low dynamite-type explosive called "cheddite". Note: all chlorate mixes are sensitive to both friction and shock.

F. Cherry Bomb — although a cherry bomb with a fuse assembly appears to be dangerous, actually the small charge will not give sufficient velocity to fragments glued or taped to it. The grenade is dangerous only if fragments hit the soft part of the body (throat, face, eye).

None of the above fillers is truly an explosive with detonation velocity and power approaching that of a high explosive. The expedient HE fillers which are powerful yet relatively safe to handle and manufacture are:

ANFO

As the name implies, the material is a blend of *A*mmonium *N*itrate and *F*uel *O*il. Its preparation is the ultimate of simplicity itself as shown below.



IMPORTANT: After ANFO is blended, transfer to a storage container with a tight fitting cover and close the cover to keep moisture away.

ANFO NOTES:

1. AN warmed above 32.1° C undergoes crystal change from large to small crystals, causing higher pressures at ignition.
2. Pure AN is less sensitive than ANFO.
3. Addition of metallic powders of aluminum, lead or zinc sensitizes AN, lowering its decomposition temperature (sometimes below 100° C), hence galvanized metal containers should not be used for storage of ANFO.
4. ANFO performance is controlled by:
   a. Confinement.
   b. Charge diameter.
   c. % of fuel oil.
5. Good performance of ANFO requires:
   a. Primer and booster must have high detonation pressure/velocity.
   b. Primer and booster must have adequate diameter and length in relation to the main charge.
6. Compressed ANFO is less sensitive than loose ANFO of the same composition. Loose ANFO may be detonated with a blasting cap only if the assembly is well contained; compressed ANFO requires a booster for positive ignition.
7. ANFO filler should be about 2½" in diameter for positive shock wave propagation.
8. ANFO sensitivity to primer-booster may be improved by the addition of aluminum powder.
9. ANFO without additives degrades in storage due to gradual seepage of oil.
10. A 1:1 mix of gasoline and motor oil may be substituted for the diesel oil.
11. Fertilizer grade AN is quite suitable for ANFO.
12. ANFO requires a booster for positive ignition, hence is not as suitable for expedient grenade filler as is the mix "E".

"E" FILLER PREPARATION

Equipment:

1. Balance, 1000 gram capacity, plus or minus 0.2 gram accuracy.
2. Graduated glass cylinder, 500 ml capacity.
3. Large bowl, kitchen type (stainless steel, glass or glazed earthenware).
4. Soup spoon, stainless steel.
5. Plastic spatula, kitchen type.
6. 1 quart (approx.) covered containers. Surplus ice cream, yogurt, etc., containers work nicely.
7. Sieve, kitchen type.
8. Crusher (large flat board and a smaller, brick sized piece of wood).

Safety Precautions:

1. Keep away from open flame.
2. Keep away from other explosives.
3. Keep work area and equipment clean.
4. Keep all materials covered and away from work area.
5. Scrap filler is destroyed by dilution with boiling water and flushing with hot water.

Since the mixing temperatures and sequence have a marked effect pn the filler density and sensitivity, the following procedure is only indicative of the variants possible.

Procedure:

1. Filter an adequate quantity of each solid material through the sieve.
2. If necessary crush the AN by spreading a cupful on the large crusher board and rub vigorously with the small piece of wood until the material is broken down to a size that will pass through the sieve.
3. Weigh the required quantity of each material.
4. Place the screened and weighed materials in separate containers and close tightly.

Note: when all materials (solid and liquid) have been prepared, the batch is ready for blending.

5. Place AN into the mixing bowl.
6. Add boiling water and stir until all AN dissolves (AN solubility is 580 gm/100 ml at 80°.
7. Blend the gelling powder and potassium nitrate (or sodium nitrate) in a separate container.
8. Add the mix from step 7 to the hot AN solution.
9. Stir for about 3 minutes.
10. Add sensitizer (aluminum).
11. Mix contents of bowl thoroughly.
12. Dissolve thickener/cross-linking agent in a little hot water and add to the bowl's contents.
13. Add mixed stabilizer and enhancer to the filler mix.
14. Blend thoroughly for 5—10 minutes, or until mix is free of lumps.
15. Pour filler into the grenade body, up to the level mark.

EXPEDIENT GRENADE FILLER "E"

Stable in storage yet sensitive enough to be detonated by a No. 6 blasting cap.

	FUNCTION IN MIX	MATERIAL	% BY WEIGHT	GRAMS REQUIRED FOR ONE 6 oz. CAN GRENADE
1.	Explosive oxidizer	Ammonium nitrate	55	140
2.	Secondary explosive oxidizer	Potassium or sodium nitrate	10	22
3.	Fuel & sensitizer	Aluminum powder (blend of flaked and atomized)	20	50
4.	Gelling agent	Gelatin or starch (kitchen grade)	2.5	6.5
5.	Thickener	Potassium dichromate (or Cr, Fe, Sn sulfates, nitrates or chlorides) i.e. kitchen grade borax	1	2.5
6.	Retardant, prevents filler swelling and gas generation in storage	Urea	0.5	1.25
7.	Buffer, enhances retardant effect	KH_2PO_4 L/NaOH (in 29/1 mol. ratio)	0.3	0.7
8.	Blending and gelling media	Water (preferably boiled or distilled)	15	37
			Total Weight	200 grams

(Note: Items No. 6 and No. 7 may be eliminated if long storage is not expected; they will not affect the explosive performance.)

"E" FILLER NOTES:

1. The user should keep in mind that the described mix is flexible in composition, i.e. many variations are possible.
2. Up to 1/4 of the potassium or sodium nitrate may be replaced by finely powdered coal (this improves the oxygen balance of the reaction).
3. Gelling materials (starch, gelatin) may be replaced by various natural gums, such as arabic, tragacanth, etc. The best and most effective gelling material is guar gum.
4. Addition of sugar as fuel (up to 6%) improves the filler sensitivity and may be a substitute for aluminum in this respect.
5. The described filler is equal in strength to a 60-75% NG dynamite.
6. This expedient HE filler is presently the optimum choice.

16. Insert a spacer for the detonator into the molten filler.
17. Place grenade body with spacer and filler in a warm air dryer until filler coagulates into a uniform, gelatinous, tough and elastic mass.
18. Withdraw detonator spacer from the filler. The grenade is now ready for closing and fuzing.

FUZE

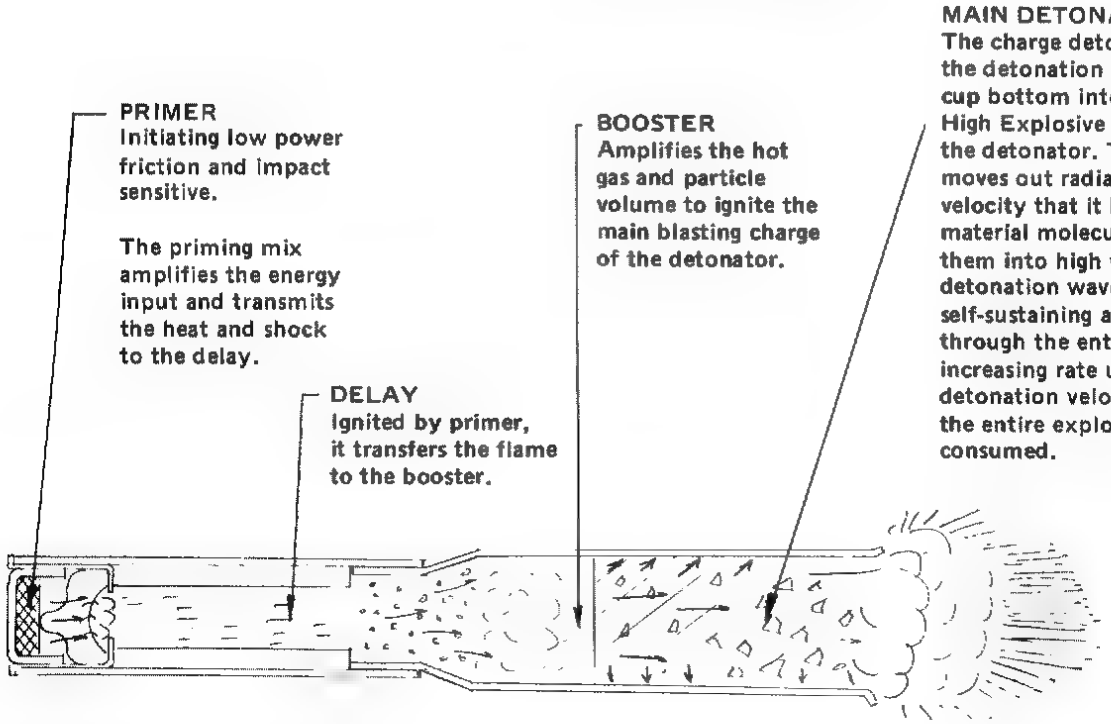
The expedient grenade fuze, like its counterpart, may be of delay or impact type. Experience has shown that the delay type is generally preferred. Although the striker-actuated delay fuzes are simpler to use, their construction is relatively costly and complex when compared to the classic match-saftey fuse actuation. Therefore the majority of expedient fuzes are the classic model:

MATCH (CIGARETTE LIGHTER)
↓
SAFETY FUSE (DELAY ELEMENT)
↓
DETONATOR

The matches and/or cigarette lighters are ubiquitous commercial items readily available anywhere, hence a manufacturing description is not required.

EXPLOSION MECHANICS

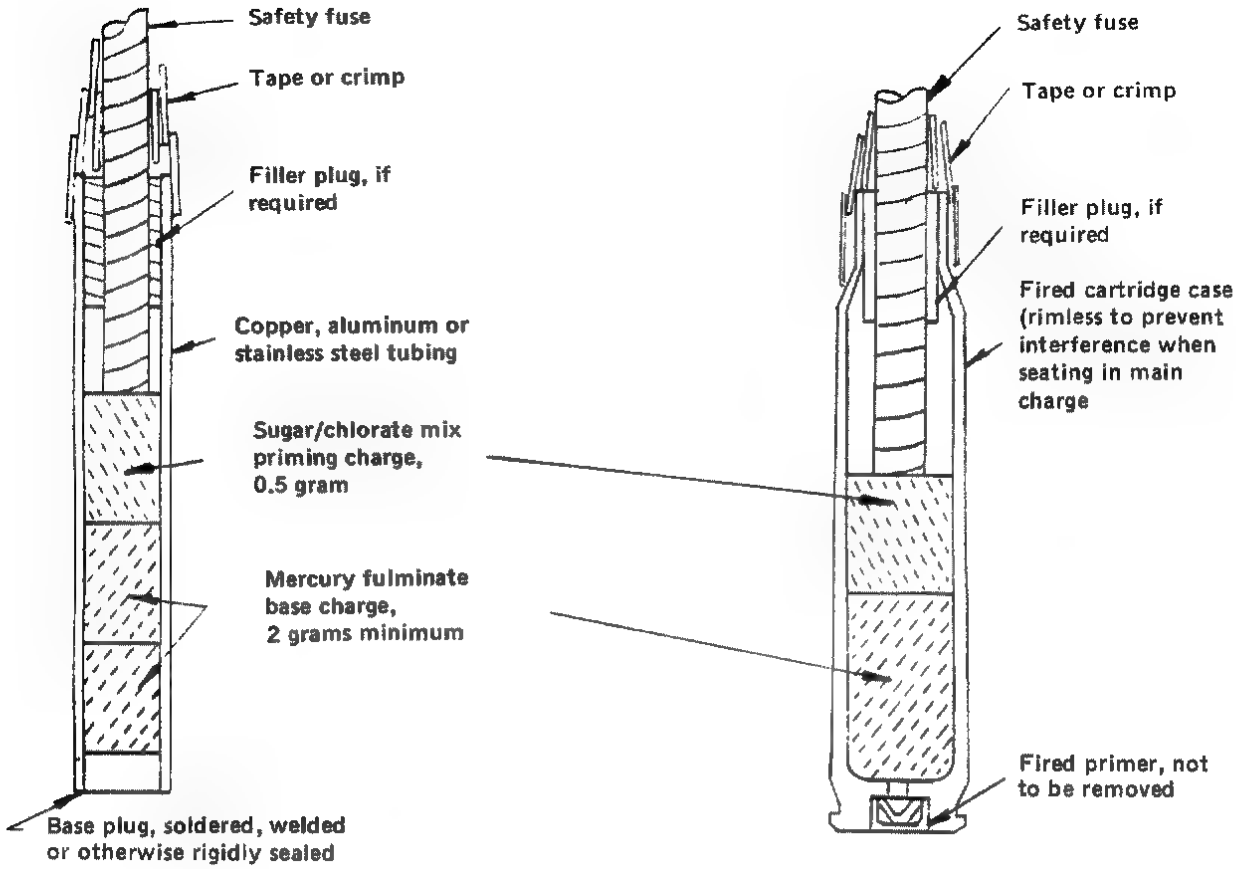
Schematic illustration of an explosive system consisting of initiating—delay—explosive elements.



The fuze assembly must be secured to the HE filler by tape, etc., to prevent the detonator being blown out by its own blast and without igniting the HE filler.

The detonator bottom must rest solidly against the HE filler for good detonation wave transfer.

MATCH HEAD ACTUATED, DELAY TYPE EXPEDIENT HAND GRENADE FUZE



NOTES:

1. The shell should be strong, rigid and uniform for easy filling.
2. The detonation velocity (power) of the blasting cap charge increases with compression.
3. Sensitivity of mercury fulminate does not increase with compression, only its efficiency.
4. Increase in charge weight may compensate for compression.
5. Sugar/chlorate priming is used to assure hot flame for positive ignition of fulminate.
6. Firecracker fuse, rocket fuse and improvised fuse do not produce sufficient heat to ignite mercury fulminate directly.
7. Externally burning fuse must be checked for performance as it may extinguish by contact with filler plug, causing a misfire.
8. Compression of the charges may be done with a wooden plug.
9. Commercial blasting caps compress mercury fulminate with pressure of 210 Kg/cm^2 (from gravimetric density of 1.75 to pressed density of 3.5); such charges have a detonation velocity of 4000 m/sec.
10. A charge of 2 grams MF is required for positive ignition of ammonium nitrate explosives.

The manufacture of expedient safety fuse and a detonator is given below.

It must be borne in mind that the manufacture of an expedient grenade is not as frightening as its use. While the HE filler and fuze detonator and primer are dangerous per se, their manufacture and/or handling is done under controlled conditions with full attention to all safety procedures.

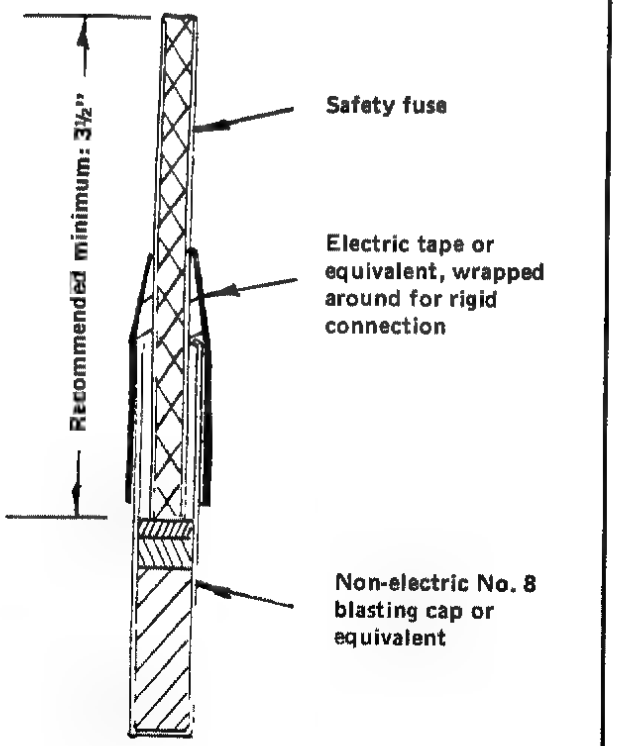
The actual danger is present when the end user holds the grenade in one hand while lighting the fuse with a match held in the other. If the fuse burning rate is defective, it can cause a premature, usually fatal, detonation, or it can produce a dud which may go off during recovery. It is therefore vital that a grenade fuze works utterly reliably. It is also evident that the heart of the fuze is the delay

component. Even though non-explosive by itself, it demands the utmost attention during manufacture and inspection.

Commercially available materials which may be used as expedient fuse would include:

1. 3/32" dia. red firecracker fuse with a single waterproof coating, externally burning. After burning, only ashes are left.
2. 1/8" dia. green firecracker fuse with double waterproof coating, internal burning. After burning, burned out body is left.
3. "Jetex" model rocket fuse, 1/32" dia. This is brown in color and has a fine copper wire inside to assist in heat transfer. It is externally burning and the wire remains after use.
4. "Wick line" model rocket fuse, 3/32" dia. This is red in color, externally burning, and leaves only ashes.

MATCH HEAD ACTUATED, DELAY TYPE EXPEDIENT DESIGN HAND GRENADE FUZE



NOTES:
1. Commercial burning fuse has a burning rate of 40 + 4 sec. per 1 foot of fuse.
2. Test burning rate of sample of fuse at expected ambient condition before cutting and assembling fuzes.

The burning rates of the above fuses vary not only between models but also from lot to lot, hence it is imperative that they be tested before use.

(Remember, "fuze" is a device to set off HE. "Fuse" is an incendiary string or tube carrying flame to the priming mixture.)

Expedient fuse is a column of highly incendiary matter contained inside a tube or incorporated into a carrier (string). It must have the following characteristics:

a. Ignite readily from an open flame or spark.
b. Burn uniformly throughout the entire length.
c. Transfer enough flame and/or heat to ignite the detonator.

There are several possible methods to accomplish the above. The simplest and safest are described in the text. Yet, regardless which method is selected the following rules apply in the fuse manufacture:

1. Materials and components must be uniform and from the same source.
2. Any change of component or procedure must be treated as a separate batch (or lot) and the finished fuse must be tested accordingly.
3. Actual burning rate must be tested by measuring the time it takes to burn at least 10 inches of fuse.
4. Burning rate test should be performed under conditions as close as possible to those under which the fuse is intended to be used.
5. Expedient fuse is relatively brittle, especially the string type, hence it must be handled with care to prevent damage.
6. Finished fuse should be stored in a tightly closed container in a cool, dry place.
7. An external wrapping of tape or paper and an additional waterproof coating increase the burning rate of fuse as compared to an untaped fuse.
8. A variable burning rate is the main problem in fuse manufacture; careful attention to every construction detail reduces this problem considerably.

Typical fuse mix compositions appear at the top of page 36 (parts by weight).

TYPICAL FUSE MIX COMPOSITIONS

Oxidizers:	Potassium or Sodium nitrate	6	6						
	Potassium chlorate			6	6	6			
	Potassium perchlorate						6	5	2
Fuels:	Sulfur	2		2	1			5	2
	Charcoal dust	1							
	Sugar, brown		4			4	5		
Heat transfer carrier:	aluminum powder				2			2	
Binder:	Dextrine	0.5		1					1

Typical commercial fuse mix consists of (by weight):

Potassium nitrate	63
Sulfur powder	24
Charcoal dust	14

Nitrate mixes are more reliable, but slower burning than chlorate mixes. Furthermore, chlorate mixes are more sensitive to friction impact and spark, requiring extra care in handling.

In production the nitrate mixes are usually measured, blended and charged in dry form. The chlorate mixes are blended and charged in hot saturated solution.

EQUIPMENT (to manufacture expedient fuse):

1. Balance, 500 gram capacity, plus or minus 1 gram accuracy.
2. Deep, narrow glass or porcelain jar (an empty olive jar, etc.).
3. Thin wood or aluminum rod about 10" long.
4. Storage container with tight fitting lid (Mason jar, etc.).
5. Glass or porcelain pan-like, shallow container (kitchen dish).
6. Pot for boiling water.
7. Source of heat (stove).
8. Empty coffee can or other suitable can of similar size.
9. Sieve, kitchen type.

MATERIALS (additional to fuse mix):

1. Plastic soda straw.
2. Masking or electrician's tape.
3. Clean tap water.
4. Cotton string (braided type), washed in boiling water, then dried.

Dry Nitrate Mix Preparation And Fuse Charging

1. Weigh required quantity of materials.
2. Sift weighed materials through sieve.
3. Place screened (sifted) materials into cylindrical can and close lid.
4. Roll closed can back and forth on flat surface until contents is of uniform color and well blended.
5. Place fuse mix into a deep jar.
6. Push the end of the straw into the mix repeatedly until it becomes tightly packed throughout its length (the thin rod is used to assist in the packing process).
7. Waterproof the fuse by wrapping tape spirally around the fuse and closing both ends.
8. Store fuses in tightly closed container in cool, dry place.

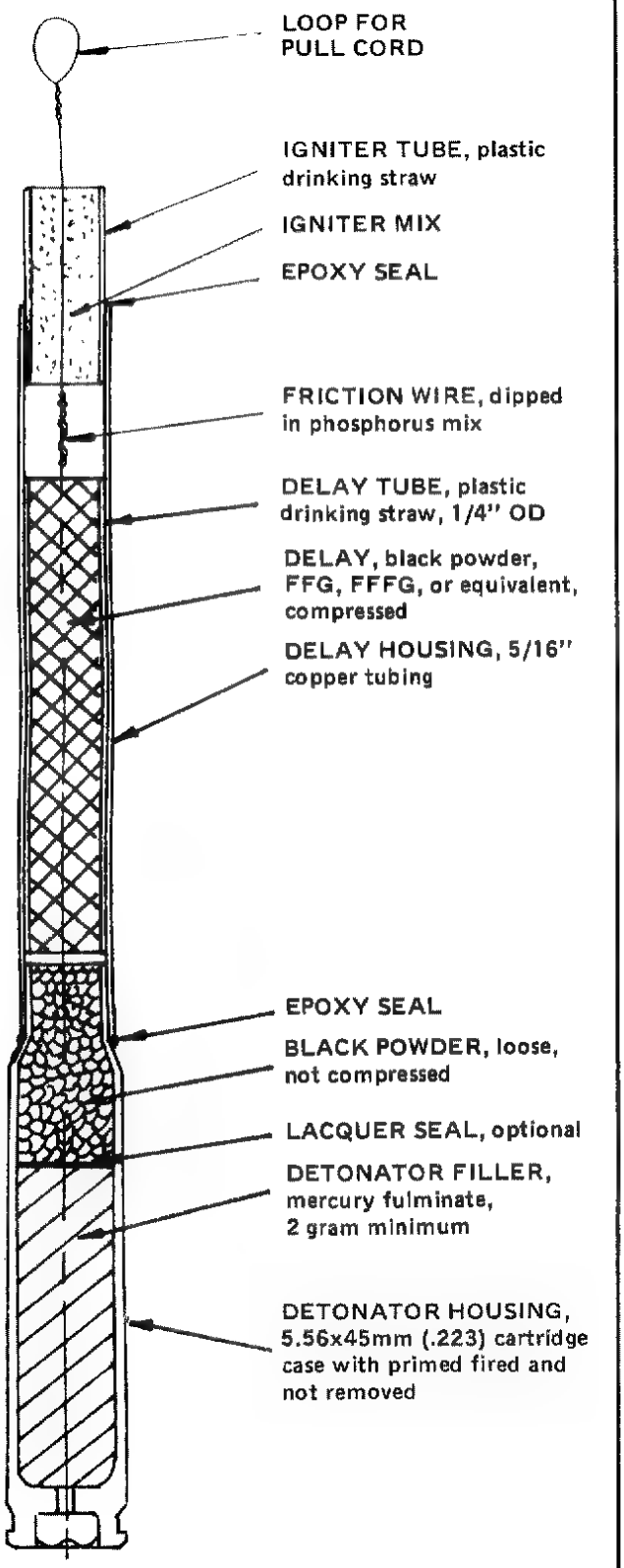
Note: If plastic straw is not available, take a 2" wide strip of tissue paper or masking tape and:

a. Crease the paper or tape lengthwise.
b. Pour a uniform quantity of the fuse mix into the crease.
c. Fold the paper or masking tape over.
d. Fasten the paper with tape.
e. Trim off excess paper or masking tape with scissors.

Not having a uniform cross-section, this fuse may not burn as uniformly as the other types.

Wet Chlorate Mix Preparation And Fuse Charging

1. Weigh and place the required quantity of chlorate into the shallow container.
2. Add hot water sufficient to dissolve the chlorate completely.
3. Weigh and place the required quantity of sugar into a separate container.
4. Add hot water sufficient to dissolve the sugar completely.
5. Add sugar solution to the chlorate solution.
6. Weigh, sift and add the remaining components to the solution.
7. Blend components with wooden or plastic spatula until thoroughly mixed.
8. Immerse washed string in the wet mix.
9. Gently rub paste/solution into the string braids until the string is thoroughly saturated.
10. Hang the string vertically so it will dry straight.
11. Wash all containers, stirrers and surfaces which may have solution and/or crystals



adhering to them with water (preferably hot).

12. Waterproof the dried fuse by wrapping tape spirally around it and closing both ends.

Friction Igniter Expedient Type Fuse

The friction igniter is used to ignite the fuse delay element prior to throwing the grenade. Because of its effectiveness and reliability this fuse was used by the German Army through two World Wars in the Model 24 grenade. This type of fuse is currently in use by the armies of several small countries.

The manufacture of this igniter is described below:

EQUIPMENT

1. Balance type scale, 50 gram capacity, 0.1 gram accuracy.
2. Cylindrical glass tumbling jar, approximately 50 ml capacity (jam or peanut butter jar is okay) with cover — 2 required.
3. Graduated cylinder, 50 ml capacity.
4. Small pliers.
5. Base, die, punch, ejector (same as used for delay element).
6. Piece of cloth or paper towel.
7. Piece of wood (tongue depressor).
8. Small brush.

MATERIALS

1. Plastic soda straw, 1/4" nominal OD.
2. Wire, approximately 0.02" diameter x 5" long (one each per igniter); electric cable, picture hanging wire, etc., are okay).
3. Shellac, flake.
4. Red phosphorus.
5. Ethanol (denatured okay).
6. Potassium chlorate.
7. Powdered charcoal.
8. Dextrin (or starch).
9. Acetone (or nail polish).

PROCEDURE

1. Weigh out 0.1 gram shellac.
2. Dissolve shellac in 2 cc alcohol.
3. Slowly add 3 grams of phosphorus.
4. Blend and keep covered to prevent evaporation.
5. Cut off 5" of wire, bend over 1" and twist into a tight spiral.

6. Dip twisted end of wire into shellac and allow to partially dry.
7. Dip twisted end of wire into phosphorus solution and allow to dry.
8. Weigh out 9 grams of potassium chlorate and place into tumbling jar.
9. Weigh out 1 gram of charcoal and place into tumbling jar.
10. Weigh out 1/2 gram of dextrin and add into tumbling jar.
11. Close the jar cover.
12. Tumble the components by gently rolling the jar back and forth until the contents is of a uniform color and well blended.
13. Empty the jar's contents onto a sheet of paper.
14. Add water, drop by drop, while blending the mix with the tongue depressor, until the mix becomes a humid paste.
15. Cut a piece of straw approximately 1/2" long.
16. Insert straw into die.
17. Use tongue depressor to fill straw with wet mix.
18. Wipe all loose mix particles from die with wet cloth.
19. Use ejector punch to push mix-filled straw from die.
20. Gently push wire through the approximate center of mix until wire protrudes from the opposite end (see illustration).
21. Phosphorous coated section of wire should be 1/4" below the bottom of the straw.
22. Wipe all loose mix particles from the wire with a wet cloth.
23. With a small brush apply a drop of acetone to the exposed mix at each end of the straw.
24. Dry the finished igniter for at least 48 hours at a maximum temperature of 45^{O} C.
25. Test a few samples of dry igniters from each lot for performance.
26. Store igniters in a tightly closed container until assembly into fuze; protect them from mechanical vibration or impact.

Striker Actuated Expedient Type Fuze

EQUIPMENT

1. Hacksaw.
2. Fine, half-round file.
3. Rat-tail file.
4. Drill with assorted drill bits.
5. Pliers, electrician type.
6. Delay compression fixture (see drawing).
7. Arbor press, 3 ton capacity minimum.
8. Safety razor blades.
9. Fine sandpaper.
10. Bench vise.
11. Bench type manual spring winder.

MATERIALS

1. 5.56x45mm cartridge case, fired but not deprimed.
2. .30 M1 carbine case.
3. Small pistol primer.
4. Black powder, preferably FFFG type.
5. Mercury fulminate.
6. Lacquer.
7. Epoxy cement.
8. Copper tubing, 5/16" OD (delay housing).
9. Plastic straw, 1/4" nominal OD (delay tube).
10. 10 penny nail (striker pivot pin).
11. 8 penny nail (safety pin).
12. Mouse trap spring, or 0.035" dia. music wire (striker spring).
13. Flat steel strip stock (striker and safety lever).
14. 3/4" square channel.
15. Masking or electric insulation tape to close delay vent holes).

OPERATIONS

Detonator sub-assembly.

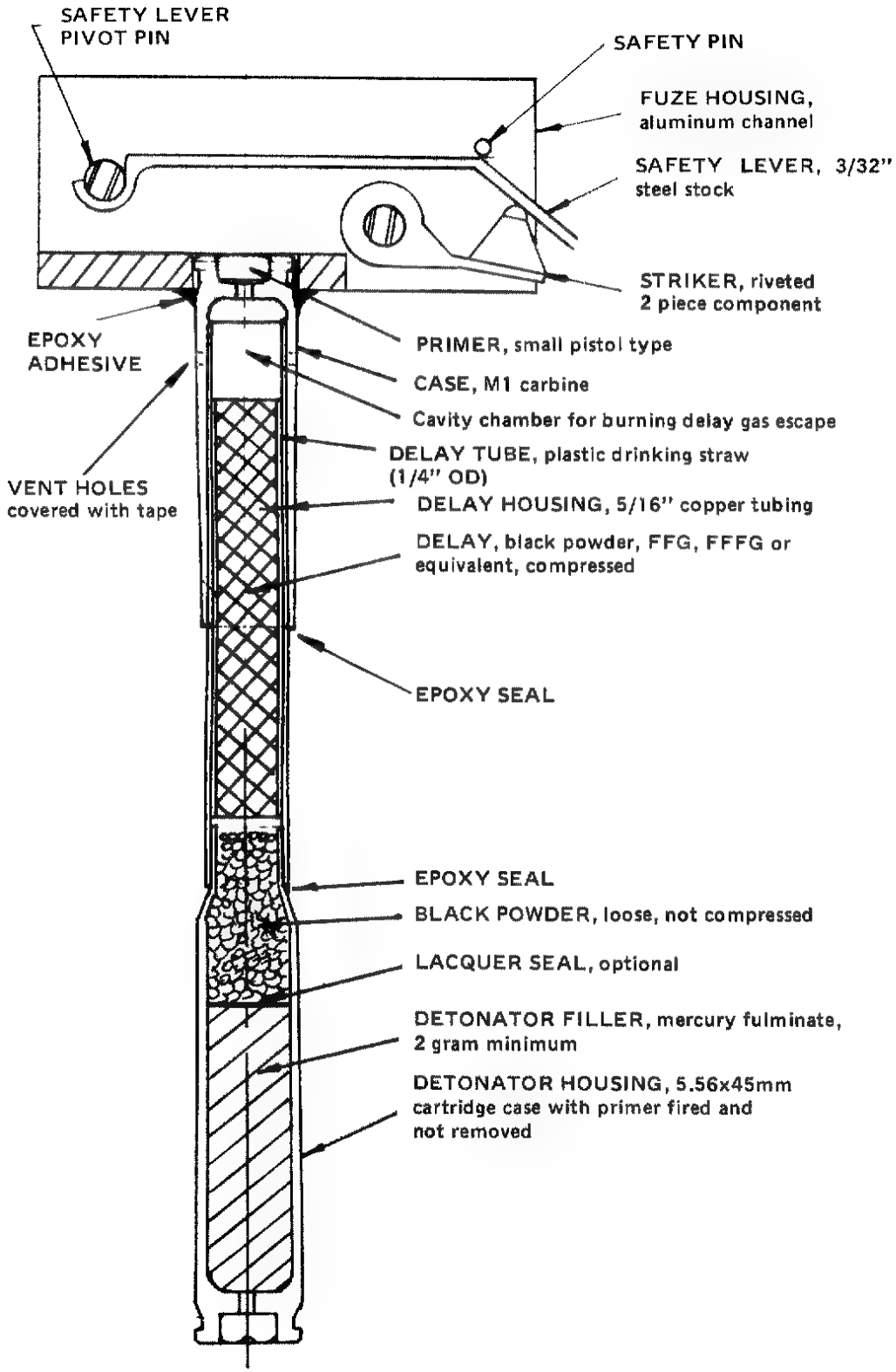
1. Wash, dry and inspect empty rifle case.
2. Preparation of mercury fulminate.
3. Charging mercury fulminate into the case.
4. Lacquer sealing mercury fulminate.
5. Lot inspection and testing of assembled detonator.
6. Packing and storage of accepted detonator lot.

The key element of an expedient grenade fuze is the detonator. Like its military counterpart, it consists of a metallic shell, sensitive HE charge and a primer.

Although any tubular material seems suitable for the shell, only copper and aluminum are used for the following reasons:

a. Non-reactive chemically with the HE charge.
b. Reasonably corrosion resistant.
c. Soft enough for good extrusion.

STRIKER ACTUATED EXPEDIENT TYPE HAND GRENADE FUZE



d. Strong to withstand HE charge compression.
e. Shell walls are rigid enough to protect the HE charge from mechanical damage.
f. Shell is strong enough to hold the HE charge to reach detonation instead of just burning.
g. Material is of uniform quality and readily available at reasonable cost.

Plastic materials have been tried but found lacking in one or more of the above requirements.

Seamless copper or brass tubing (available from plumbing supply distributors) is the best uniform and readily available material. However, shells have been made from aluminum tubing, car radio antennae, and fired but not deprimed rifle cartridge cases.

When using tubing:

1. Cut tubing into uniform length sections about 2.5" long.
2. Chamfer and clean off burrs at both ends of section.
3. Insert a snug fitting plug into one end. It is preferable that the plug be made of the same material as the tubing.
4. Secure the plug as well as possible. If brass or copper, use solder; others glue with epoxy or other strong adhesive.

Note: If tubing end is closed by folding and flattening it, do use a hard steel mandrel inside the tube to protect the shell walls from deformation in the charge area.

Having made the shell, proceed to make the explosive filler. Although military and commercial blasting caps/detonators use RDX, PETN, nitromannit, etc., the expedient detonators should use mercury fulminate for the following reasons:

a. Raw materials are readily available commercially.
b. The equipment is simple and readily available.
c. The process is simple.
d. MF is easily ignited by black powder type fuse without the need for a primer.

Mercury fulminate preparation and the final product characteristics are given in the appendix.

The detonation velocity of a detonator (blasting cap) charge increases when the charge is compressed. Following are typical values:

MATERIAL	DENSITY Gravimetric	DENSITY Compressed
Mercury Fulminate	1.75	3.5 avg.
PETN	0.8	1.5
RDX	0.8	1.45
		1.65

	COMPRESSION PRESSURE Kg/cm^2	DETONATION VELOCITY m/sec
Mercury Fulminate	211	4000
PETN	350	7500
RDX	750	7700
	2100	8200

The high densities and the high compression pressures of RDX are achieved safely with wax desensitized material only.

Procedure For Assembly Of Expedient Blasting Cap (Detonator)

Note: Follow all standard safety procedures when handling explosives.

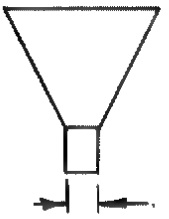
PREPARATION:

1. Inspect all equipment to assure that it is clean and in good working order.
2. Inspect the shell to assure it is clean and free of mechanical defects inside and out.
3. Place the shell into the charge block; it should slide in freely yet snugly.
4. Weigh out 1.0 gram of dry mercury fulminate (on a piece of paper).
5. Place funnel into the shell mouth.
6. Carefully dump the measured quantity of MF into the funnel (and into the shell).
7. Check that all MF is in the shell and tap the block lightly with a finger to settle the MF at the shell bottom.
8. Remove the funnel from the shell.
9. Insert the seating punch gently into the shell until it rests on the MF.
10. Place the whole assembly in the press and pre-compress the MF manually.
11. Place the hooked weight on the end of the press arm for final compression. This assures that the final force is always the same.
12. Remove the block assembly from the press.

EQUIPMENT REQUIRED FOR ASSEMBLY OF EXPEDIENT BLASTING CAPS

SCALE
Capacity: 50 grams
Accuracy: plus or minus 0.1 gram

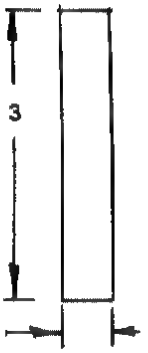
CHARGING SPOON
Material: Non-sparking (plastic, stainless steel or aluminum



FUNNEL
Material: Non-sparking (plastic, glass or aluminum)

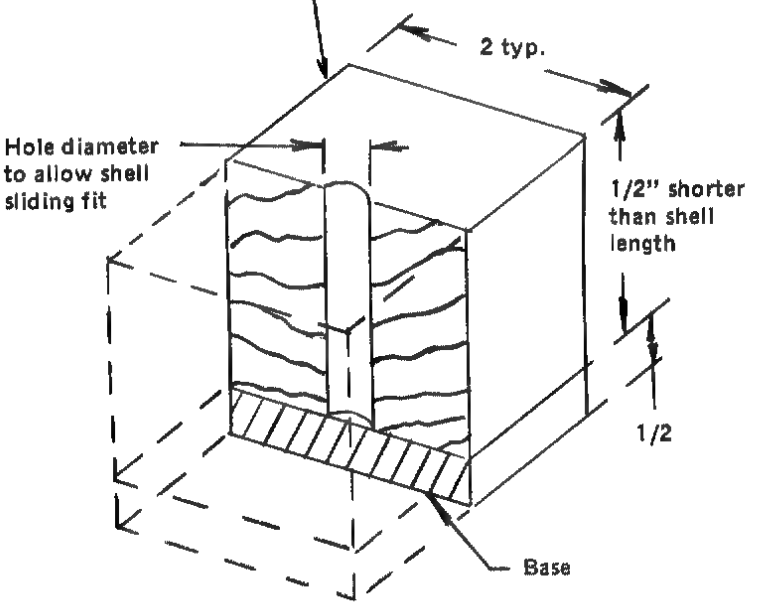
Diameter to fit inside of shell mouth

SEATING PUNCH
Material: Non-sparking, hard wood or aluminum

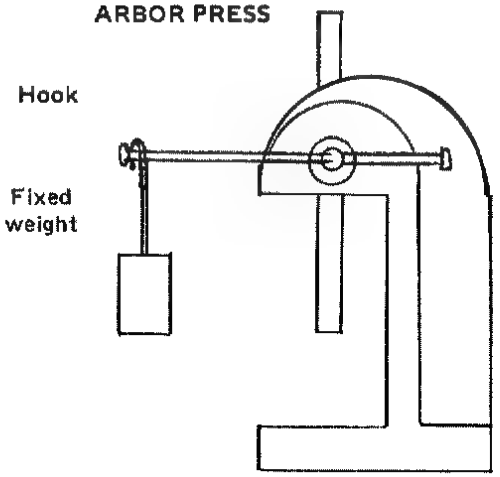


Diameter to have sliding fit inside shell

CHARGING BLOCK (sectioned view)
Material: Hard wood top, hard wood or aluminum base



ARBOR PRESS



Note: To produce a uniform final force use hooked weight

13. Gently withdraw the seating punch.
14. Inspect the compressed MF.
15. Repeat steps 4-14.
16. Repeat steps 4 through 14 for the 0.5 gram charge of sugar/chlorate mix.
17. Remove the assembled detonator from the charging block and place it into a storage container (or wrap carefully in tissue paper).

Note: The finished detonator should have no less than 3/4" empty shell over the explosive charge for insertion of the fuse. The MF charge weight increase is used as a substitute for heavy compression. The sugar/chlorate primer is used for extra-positive ignition only.

Delay Sub-Assembly Steps

1. Cut a clean, 1/4" OD plastic straw to length.
2. Cut the 5/16" OD copper tubing to length for the delay housing, chamfer and clean.
3. Weigh, charge and compress a black powder charge.
4. Insert delay into housing tube.

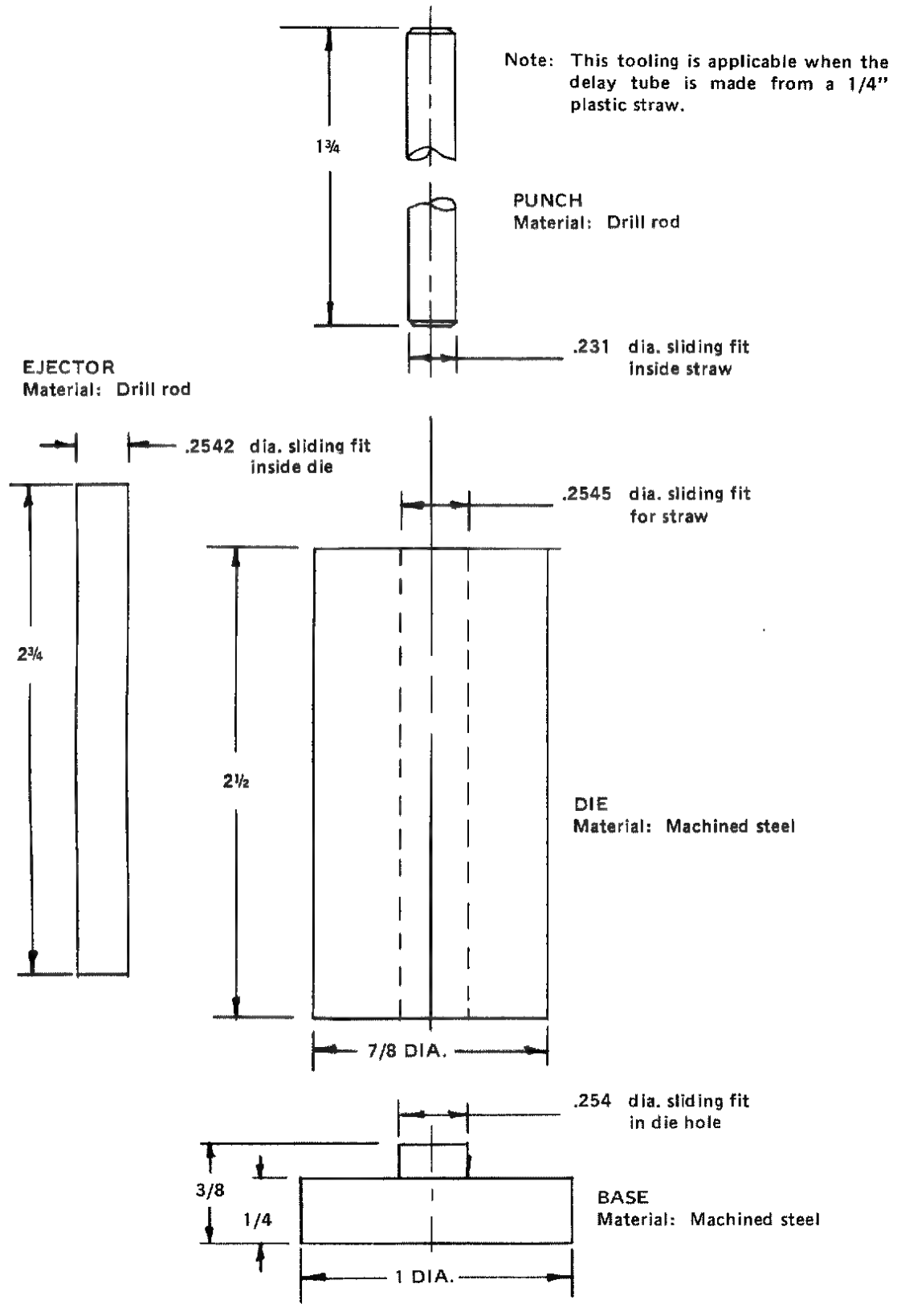
Delay Element Assembly Steps

1. Wipe clean assembly tools.
2. Visually inspect delay tube for defects.
3. Insert tube inside the tool sleeve.
4. Check that the punch enters the tube cavity correctly.
5. Place previously weighed (approximately 1/2 gram) black powder charge into the tube.
6. Insert the punch into the tube.
7. Seat the punch with preset force (about 1 ton).
8. Retract the punch and inspect the compressed pellet.
9. Repeat steps 5 through 8 until the delay column is assembled.
10. Remove the delay column assembly from the tool sleeve.
11. Visually inspect the delay column for cracks or other defects.

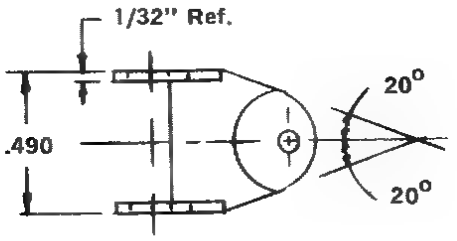
Note:

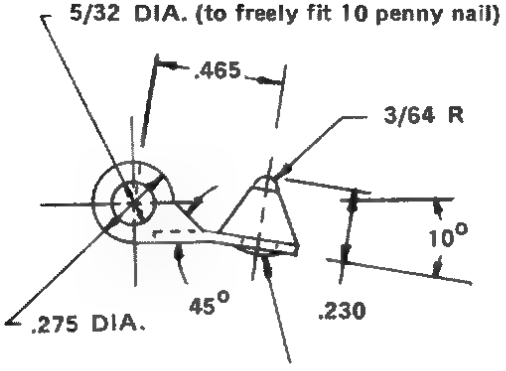
a. A crack in the delay column results in a "blow-through" and an instant functioning of the detonator.
b. The entire delay column charge should be uniformly consolidated without voids to a final height of about 1½"; this will produce a burning time of 3.5 to 4.0 seconds.
c. The delay column is compressed at 60,000 to 65,000 psi; at this pressure the burning rate is about 5.5 sec/inch.
d. A black powder delay element with a diameter of 0.125" or larger will not have erratic burning or will not extinguish because of low ambient temperature or large heat loss to the delay tube walls.
e. If possible, it is recommended to consolidate the black powder delay charge into several pellets whose height is less than the pellet diameter, to assure that a crack will not develop in the delay column. Several pellets are then seated on top of each other in the delay tube and consolidated solid.
f. The delay column assembly should be assembled with the primer and other sub-assemblies as soon as possible to avoid exposure to the atmosphere; exposures over 72 hours require holding the delay column at 46 - 3° C until immediately prior to final fuze assembly.
g. The empty plastic straw tube has a typical OD of .254"; after charging and compression of the black powder, the delay tube diameter increases to 0.256".
h. The 5/16" diameter copper tubing should be reamed out so that the black powder delay fits into the copper tubing freely; forcing the delay into the copper tube may break the black powder column causing erratic ignition timing and possible premature detonation.
i. The final length of the plastic tube should be determined by the time the assembled delay burns. A burning time of 4 seconds is the minimum safe; type of black powder, method of compression, compression force, etc., will affect the burning time. The essential is maintenance of uniformity of materials used and the methods of assembly to assure a consistent burning rate from delay to delay. Approximately 1½" will give a 4 second burning rate.
j. The cavity between the primer and the top of the delay column is essential for the delay to burn rather than explode. So is the vent hole in the primer pocket.
k. Access to X-ray equipment which would allow inspecrtion of the delay column in the fuze after final assembly is a most desirable safety feature used commercially.

DELAY ELEMENT ASSEMBLY EQUIPMENT



FUZE STRIKER

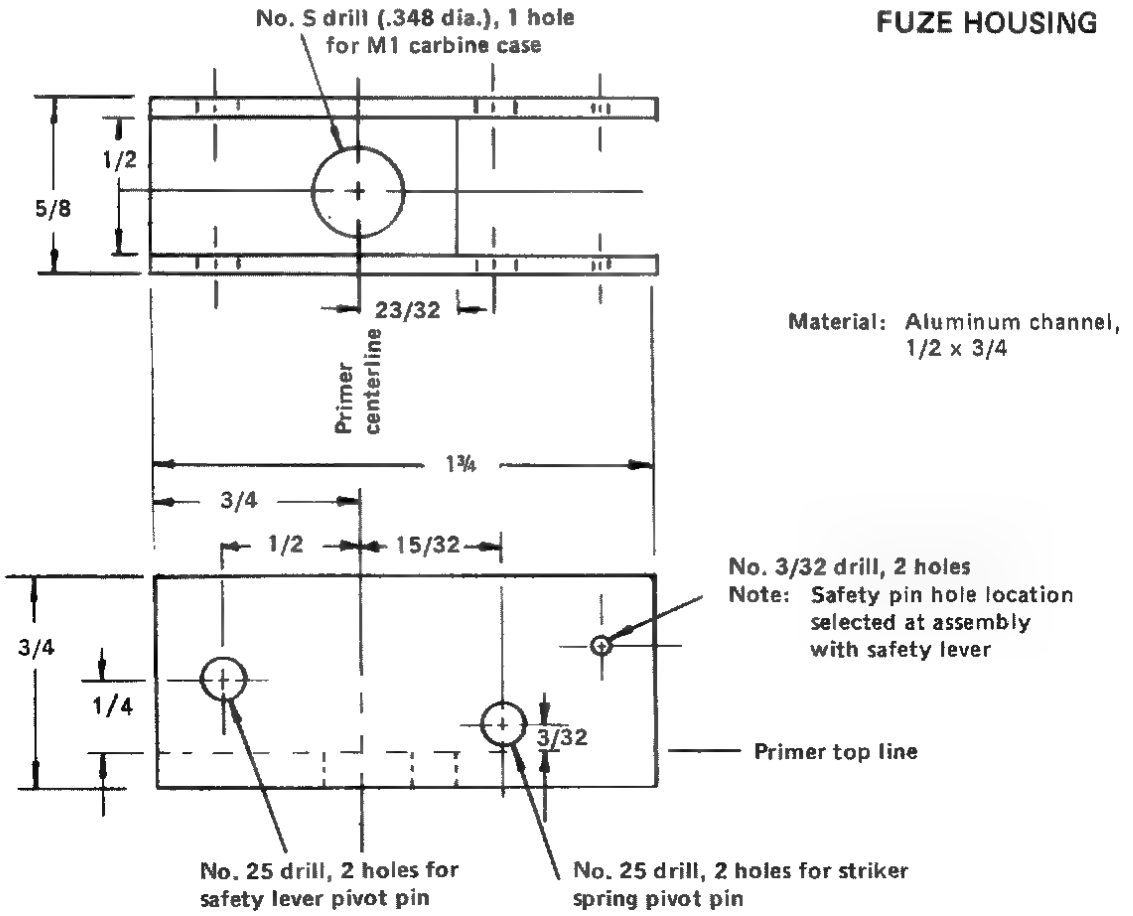




Material: 1/32" steel stock

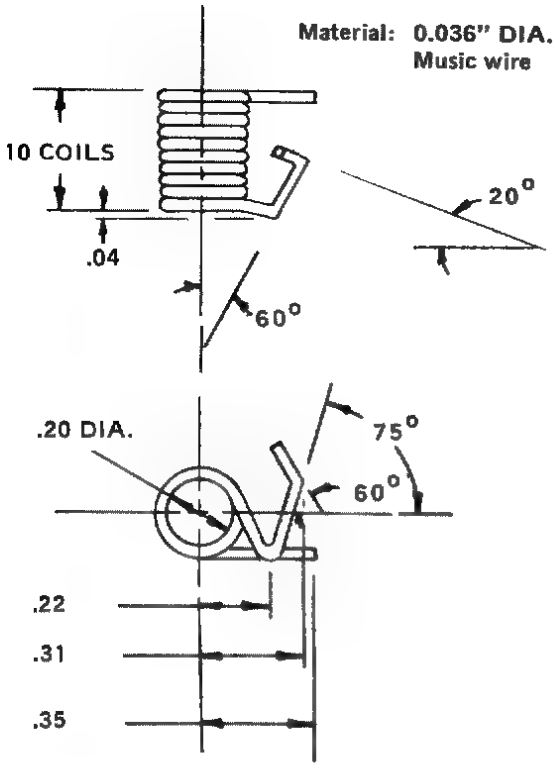
Riveted or soldered construction

FUZE HOUSING



Material: Aluminum channel, 1/2 x 3/4

FUZE STRIKER SPRING



Note: The above spring is relatively easy to make using a simple, commercial spring winder, bench vise and pliers.

A mouse-trap spring, cut in half and formed with pliers, will also make a functioning striker spring.

Delay Mix

The subject of pyrotechnic delay elements would cover several volumes. The best publicly available source is the *Aerospace Ordnance Handbook*, Chapter 10 of which describes in a clear and concise manner the problems involved in design and fabrication of the gasless mixes.

For field expedient items the delay system should be:

1. Vented This allows a more accurately reproducible functioning time than obturated (closed) gasless system.

2. Foiled The vent holes, opening to the grenade, are sealed with paper or aluminum foil, lacquer or other material until function time; this prevents humidity and foreign matters from entering the grenade.

3. Black powder mix — although the black powder is being replaced in new fuzes with such mixes as Barium chromate and Boron powders or Zirconium-Nickel mixes, it still remains in use.

Black Powder Delay Mix

ADVANTAGES:

a. Stable indefinitely if stored away from moisture.
b. Easy to ignite even at low temperature (-65° C).
c. Easy to handle and load.
d. Versatile to adjust for desired delay time.
e. Readily available.
f. Relatively inexpensive.

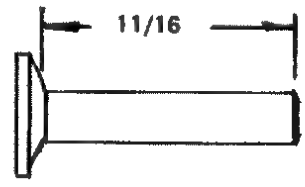
DISADVANTAGES:

a. Hygroscopic.
b. Picks up static charge easily.
c. Produces flash and smoke requiring venting.

Striker Sub-Assembly

1. Place aluminum channel into vise and cut to length.
2. Using template as a guide, drill holes in channel.
3. Deburr component.
4. Insert M1 carbine cartridge case into channel.
5. Apply epoxy adhesive to channel-case joint and allow to dry for 24 hours.
6. Seat small pistol primer in the M1 carbine case.
7. Assemble striker and striker spring to channel.

FUZE PIN

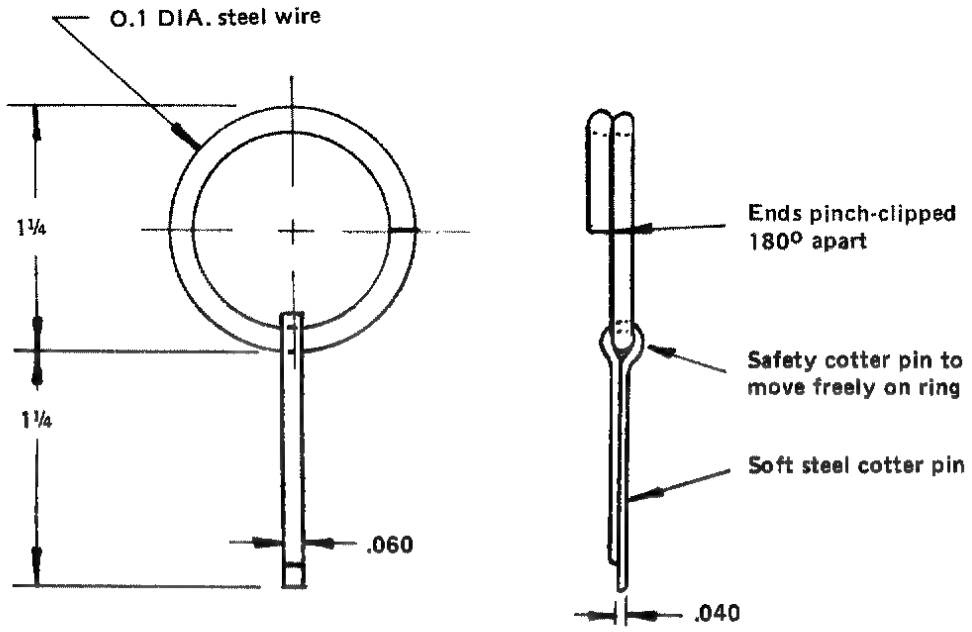


Material: Common 10 penny nail

Required: 2

Use: Striker pin safety lever pivot pin

FUZE SAFETY PIN AND RING



Note: Safety cotter pin and ring may be replaced by a 6 penny or 8 penny nail, slightly bent after insertion into the proper hole. A pull wire or string should be secured to the nail head to facilitate pull-out.

8. Cock striker, position safety lever and insert safety pin (8 penny nail).
9. Lot inspection and testing of assembled striker for primer ignition and safety pin pull force.
10. Packing and storage of accepted lot.

Primer

The modern small arms primer is the most economical, commercially readily available single item of explosive nature, suitable for the expedient grenade fuze.

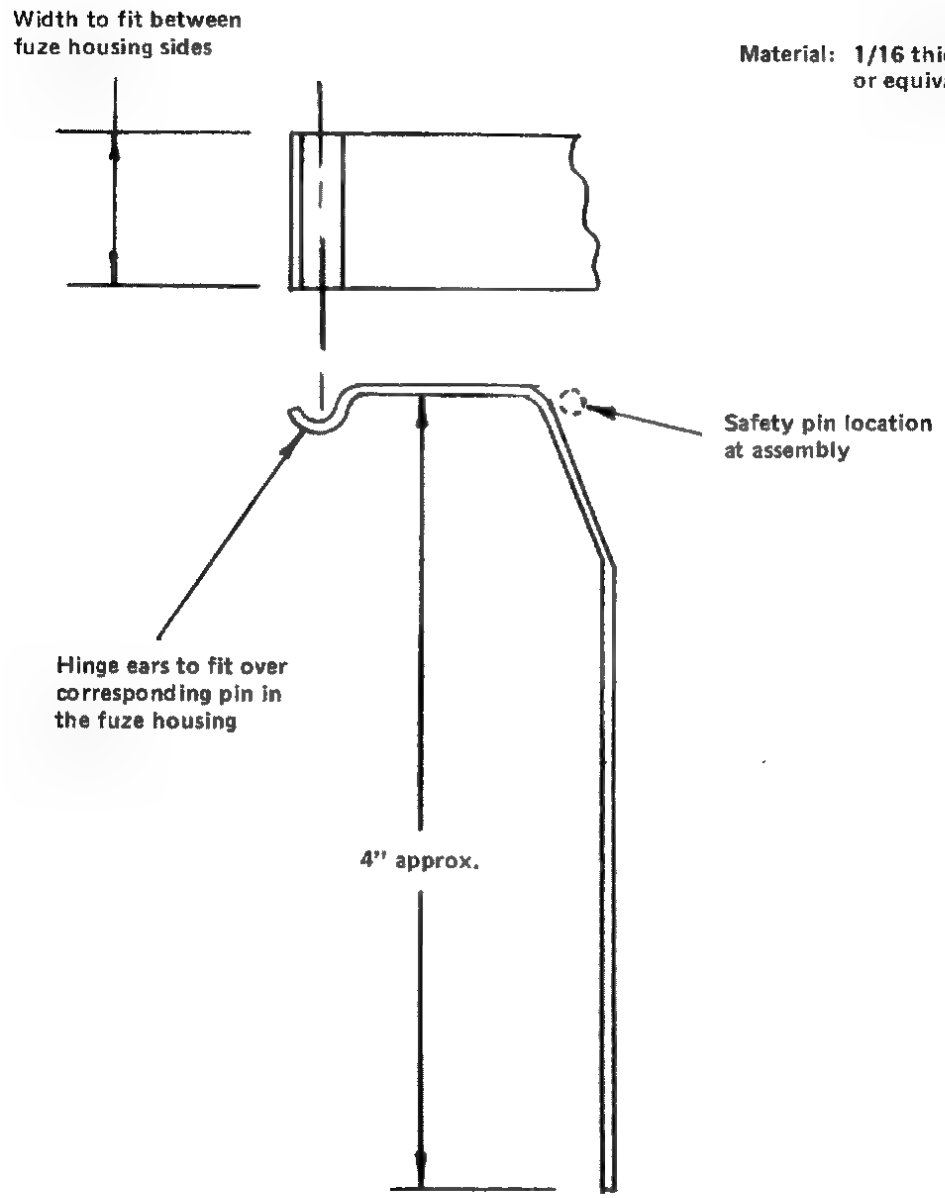
The grenade fuze should use a small pistol primer of the W-W 108 type or equivalent. This primer has the largest charge (0.32 grain) and yet fits into the M1 carbine case primer pocket. This primer will reliably ignite the black powder delay without detonation or breakage of the delay column. Other primers may be too powerful and can convert the fuze into an instantly fired cartridge, instead of a burning delay system.

Final Fuze Assembly Steps

1. Insert delay sub-assembly into the M1 carbine case.
2. Apply epoxy adhesive to bond the 5/16" tubing and the M1 case; allow to dry 24 hours.
3. Fill the 5.56x45mm detonator to the case mouth brim with loose black powder.
4. Push the 5/16" delay tube housing over the detonator case neck until it rests on the case shoulder.
5. Apply epoxy adhesive to bond the detonator and delay assemblies; allow to dry 24 hours.
6. Insert fuze into fixture.
7. Tape over vent holes.
8. Inspect, test and label each fuze lot.
9. Pack assembled and accepted fuzes in soft padded container to protect them from shock and damage.
10. Store packed fuzes in cool, dry place, away from loaded grenades.

Note: Fuzes should be assembled into the grenades only immediately prior to use.

SAFETY LEVER



Note: The above drawing is for reference only; the lever should conform to the shape and size of the grenade body. If suitable steel strip is not available, the safety lever can be made from a 1/8" dia. steel rod, bent and notched for pivot pin. However, care must be taken to prevent side movement of such a lever, causing striker release.

Expedient Incendiary Grenade

The incendiary grenade is the most common type of expedient hand grenade known. It is effective, the materials are easy to get, the manufacture is simple and relatively safe.

Incendiary grenades are partially anti-materiel, used against targets with hard surfaces such as buildings and vehicles. They also have a great panic producing effect, especially in crowded spaces. Although incendiary grenades burn and destroy property, they kill very rarely.

The choice of the grenade body (usually a bottle) requires a most careful evaluation. Following are some aspects to be considered:

Plastic Containers

ADVANTAGES:

1. Readily available.
2. Inexpensive.
3. Available in a variety of sizes.
4. Usually semi-transparent, facilitating filling.
5. Burns or melts.

DISADVANTAGES:

1. Does not fracture as well as glass.
2. May be incompatible with filler.

Glass Soft Drink Bottles

ADVANTAGES:

1. Readily available.
2. Inexpensive.
3. Fragments act as secondary projectiles.
4. Easy to fill and handle.
5. Inconspicuous.

DISADVANTAGES:

1. Fragmentation pattern is unpredictable.
2. Requires hard surface for impact.
3. Small size for optimum incendiary effect.
4. Coke bottle of the old style is too thick to fracture reliably.
5. Will break if accidentally dropped on a hard surface.
6. Will not break if hitting soft target.

Glass Wine Type Bottle (4/5 Size)

ADVANTAGES:

1. Readily available.
2. Inexpensive.
3. Fragments act as secondary projectiles.
4. Easy to fill and attach fuse.
5. Optimum size for this type of grenade.

DISADVANTAGES:

1. Fragmentation pattern is unpredictable.
2. Requires hard surface for impact.
3. Will break if accidentally dropped on a hard surface.
4. Will not break if hitting a soft target.

Although any glass bottle or jar will serve, the best all-around expedient incendiary grenade body is a standard size and shape wine bottle. However, bottles used for sparkling wines (champagnes) are

not sutiable because they have extra heavy wall construction and are very hard to shatter reliably.

The expedient incendiary fillers range from exotic chemicals to unaltered gasoline. The most readily available and effective filler is the Napalm expedient made from gasoline and soap.

Unaltered gasoline has a limited effect due to quick burning and fast runoff from the target. A mix of 2/3 gasoline and 1/3 motor oil is slightly better, but not comparable to the Napalms.

The variety of commercial Sterno type solid fuels are expensive and are not as effective as the gasoline-soap mixes.

The gelled gasoline mixes of various types are described in the Napalm Mixes chart which appears below.

NAPALM MIXES (All Parts By Volume)

Gasoline		100
Soap,	powder	55
	flakes	78
Alcohol		2.6

1. Basic napalm systems are of the gasoline-soap type. Other mixes do exist, but are not covered in this volume due to space limitations and because most of them are just a variation on the basics anyway.
2. Alcohols are added for better solubility of soaps in gasoline.
3. The use of alcohol eliminates the need for heating the gasoline. This is a most desirable feature from a safety point of view.

MATERIALS

1. Liquid fuel — gasoline, kerosene, turpentine, fuel oil, diesel oil.
2. Alcohol — ethyl alcohol (whiskey) is best, giving harder gels. Methyl alcohol (wood) or isopropyl alcohol (rubbing) give soft gel, as does antifreeze.
3. Soap — only real soap is to be used, if the word "soap" doesn't appear on the container, assume that it is a synthetic washing detergent. While soap reacts with mineral salt in water to form a sticky, insoluble scum, a detergent will not. Following are some of the soaps available commercially in retail stores:

Ivory Snow	Proctor & Gamble
Ivory Flakes	Proctor & Gamble
Lux Flakes	Lever Bros.
Chiffon Flakes	Armour
Palmolive Bar Soap	Colgate-Palmolive
Octagon Bar Soap	Colgate-Palmolive
Sweetheart Bar Soap	Manhattan Soap Co.

Bar soaps should be carved into thin flakes prior to use. Homemade soaps may be used.

GASOLINE-SOAP TYPE NAPALM

PREPARATION:

1. Fill bottom of double boiler with water.
2. Heat water until it boils.
3. Place upper pot on top of bottom pot.
4. Remove both containers to an area away from flames (or shut off source of heat).
5. Pour soap powder or chips into the upper pot to 1/4 of the pot volume.
6. Pour gasoline into the upper pot containing the soap until 1/2 of the pot volume.
7. Stir the mixture with a rod or spoon until it thickens to a paste of jam-like consistency.
8. If after 15 minutes of stirring the mixture has not thickened sufficiently remove the upper pot and place safely on ground or table.
9. Carry the lower pot back to the stove and heat the water to boiling.
10. Shut off the heat source and bring the boiling water pot back to the upper pot.
11. Place the upper pot on top of the water pot.
12. Continue stirring the mixture until the napalm reaches the required consistency.

Note: Steps 8 through 11 may be repeated several times.

13. When the desired consistency is reached transfer napalm into a tightly sealed container: store in a cool place away from sun or heat. Packed napalm will keep for months stored this way.

SAFETY PROCEDURES, INCENDIARIES

1. Follow the manufacturing procedures given in this manual exactly as written. They have been tested to give the desired results with a minimum chance of mishap.
2. Do not experiment with different procedures, quantities or materials.
3. Manufacture of incendiaries is dangerous; their purpose is to burn intensely under the right conditions: take care that no fire results during the making and/or handling of the devices.
4. Certain ingredients give off poisonous fumes, may burn the skin on contact or are easily inflammable.
5. Do not eat or place any of the materials in the mouth.
6. Wear eye protection when working with the materials or in the work area.
7. Wear protective clothing (even a lab coat helps) when working with the materials or in the working area.
8. Wash face and hands after work, before each meal and/or smoke period.
9. Wipe your work shoes with a damp cloth after work.
10. Thoroughly wash all tools and the work area with water after work.
11. Fire prevention is more important than fire fighting; prevent fire from starting.
12. Keep flammable liquids away from open flames.
13. Do not smoke in the work area.
14. Keep the work area clean and neat.
15. Clear away all equipment and materials not needed for given work.
16. Clean up all spills immediately.
17. Store incendiaries in closed containers away from heat. Do not store materials any longer than necessary.
18. In the event of fire, remove the incendiaries from the danger area, if possible, to be done quickly and safely.
19. Use large quantities of water to fight fire.
20. Horseplay is dangerous and is strictly forbidden.

Notes:

a. For cold weather use napalm should be made from gasoline.
b. For hot (tropical) use where it is exposed to direct sun make napalm from fuel oil.
c. Napalm is most effective when spread over the target surface; this starts large areas burning at once.
d. Napalm's effectiveness is increased when charcoal is added to it; this increases the fire persistency without affecting its ignition.
e For larger wooden sections and large buildings use at least one quart (1 liter) of napalm.
f. Napalm is easily ignited by fuse and/or a delay placed directly over it.
g. For use in fire bottles pour and/or transfer the napalm into the bottle right after step 13 above.

PREPARATION (When Using Alcohols)

1. Measure out the appropriate amount of gasoline and place in a clean container.
2. Add the alcohol to the gasoline and mix thoroughly.
3. Add the appropriate amount of soap to the mix and stir occasionally until the material thickens (about 15 minutes).
4. Cover the container and store in a place

well away from flames and direct sun rays.
5. Stored in in airtight container, it will keep for months.

Note: The formulation is calculated on an alcohol of 50% (i.e. 100 proof whiskey); when using rubbing or wood alcohol (isopropyl or methyl respiratory) check that its strength is adjusted correctly to 50%.

EQUIPMENT

1. Container from any material, minimum 2 quart (2 liter) capacity.
2. Stick or paddle for stirring.
3. Balance or scale.
4. Small measuring container.
5. Storage container with airtight lid.
6. Knife to cut bar soap.

FUZE

The expedient incendiary grenade fuzes are of two basic types:

A. Time (ignited by user before throwing).
   a. Rag or wick.
   b. Firecracker fuse with incendiary wrap.
   c. Highway flare.

B. Instant (ignited by impact on target).
   a. Mechanical reaction (primer striker, match head pulled against gritty surface, etc.).
   b. Chemical reaction (two or more chemicals that when combined generate heat and flame).

Regardless of which of the above systems is used, the fuze should be:

1. Safe.
2. Reliable under all expected conditions (wind, cold, rain).
3. Simple to construct.
4. Simple to operate.
5. Readily available materials.

The incendiary grenade fuze must produce hot and persistent flame (or chemical reaction) to ignite the filler positively and rapidly. An "explosive" fuze such as a "cherry bomb" is not fully reliable and may disperse the filler instead of igniting it.

The best expedient fuzes are:

1. Commercially available toy rocket fuse igniter with added incendiary pellet and/or wrap for improved filler ignition.

   or:

2. Sugar-chlorate/acid fuze.

Both fuzes and preparation methods are described below (types 1 and 2 respectively).

Sugar-Chlorate Mix

Objective: Preparation of mix for incendiary grenade.

EQUIPMENT

1. Heat resistant glass or porcelain pot, 1 pint (1/2 liter) capacity.
2. Heat source (stove).
3. Glass funnel.
4. Spoon, non-sparking material (glass, plastic or stainless steel).
5. Small glass container suitable for measuring.

MATERIALS

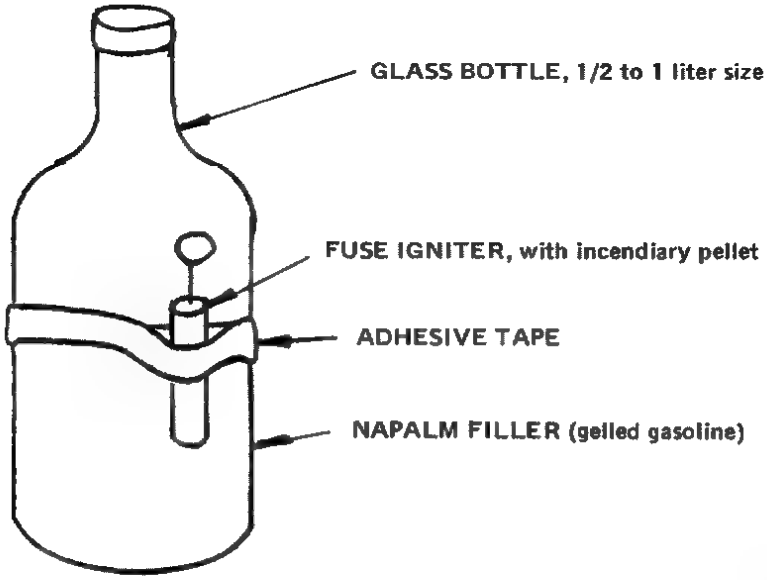
1. Sugar, granulated.
2. Water, clean, preferably distilled.
3. Potassium chlorate, granulated, no coarser than the sugar used.
4. Bottle or jar with stopper or cap, 1/2 pint (1/4 liter) capacity.

Safety precautions:
Dry potassium chlorate is sensitive to flame, spark, friction or shock.

PREPARATION:

1. Clean and dry all containers and equipment inside and out.
2. Place 6 measures of water into the pot.
3. Bring water to a boil.
4. With clean dry spoon place sugar into the measuring container.
5. Transfer 1½ measures of sugar into the boiling water.
6. Wipe the spoon clean.

EXPEDIENT INCENDIARY HAND GRENADE
Type 1



FUNCTIONING:

1. **Holding the grenade in the throwing hand, pull the igniter cord/ring to start the fire.**
2. **Throw the grenade at the target immediately.**
3. **Upon impact, the bottle breaks up, spilling the filler which bursts into flame on contact with the burning fuse.**

7. With the clean dry spoon place potassium chlorate into the measuring container.
8. Transfer one measure of potassium chlorate into the boiling sugar water.
9. Immediately shut off the heat source or remove the pot from stove.
10. Allow the solution to cool to room temperature.
11. When the solution is cool pour it into the small bottle, using a clean funnel.
12. Close the bottle securely.
13. With tap water wash off any solution or crystals adhering to the outside of the bottle.
14. Dry the bottle.
15. Wash the funnel and pot with warm water to remove all traces of the potassium chlorate mix.

EXPEDIENT INCENDIARY GRENADE ASSEMBLY

1. Clean and dry all containers inside and out.
2. Using funnel, pour gasoline gel into the wine bottle until full.
3. Close the bottle securely.
4. Flush the tightly closed bottle with water to wash off any filler from the outside surfaces.
5. Wash the funnel thoroughly with hot water.
6. Dry the closed bottle.
7. Seal the cap with candle wax (paraffin).
8. Wrap the absorbent cloth or paper around the bottle.
9. Secure the cloth to the bottle by wrapping with string or tape.
10. Using a clean funnel, fill 3 test tubes about 3/4 full with concentrated sulfuric acid.
11. Close the test tubes tightly with rubber stoppers.
12. Flush the tightly closed test tubes with water to wash off any acid from the outside of the tube.
13. Dry the closed test tubes.
14. Tape the stopper securely to the test tube.
15. Seal the taped assembly with candle wax.
16. Fasten the test tubes (3) over the absorbent cloth or paper to the bottle with tape or string.

THERMITE GRENADE

Discussion of incendiary grenades would be incomplete without mentioning the expedient thermite grenade.

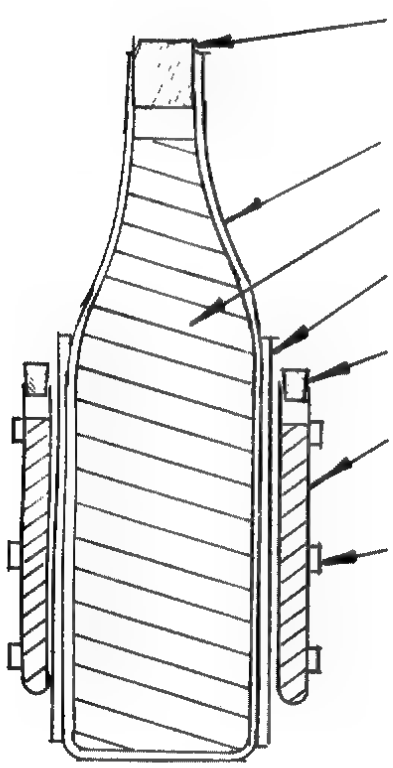
Although the preparation of thermite and the construction of a thermite grenade is described below, it is our weighted opinion that thermite is more suitable for destructive devices *placed* (not thrown) on metallic structures, vehicles, electrical equipment and such.

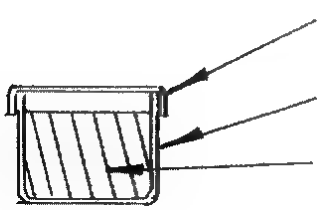
For quick effect against equipment and personnel, a gasoline gel filled bottle is preferred.

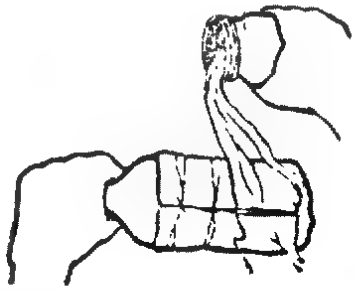
Thermite

Thermite is a mechanical mixture of aluminum powder and magnetic iron oxide. When burning it produces temperatures high enough to melt steel,

EXPEDIENT INCENDIARY HAND GRENADE
Type 2



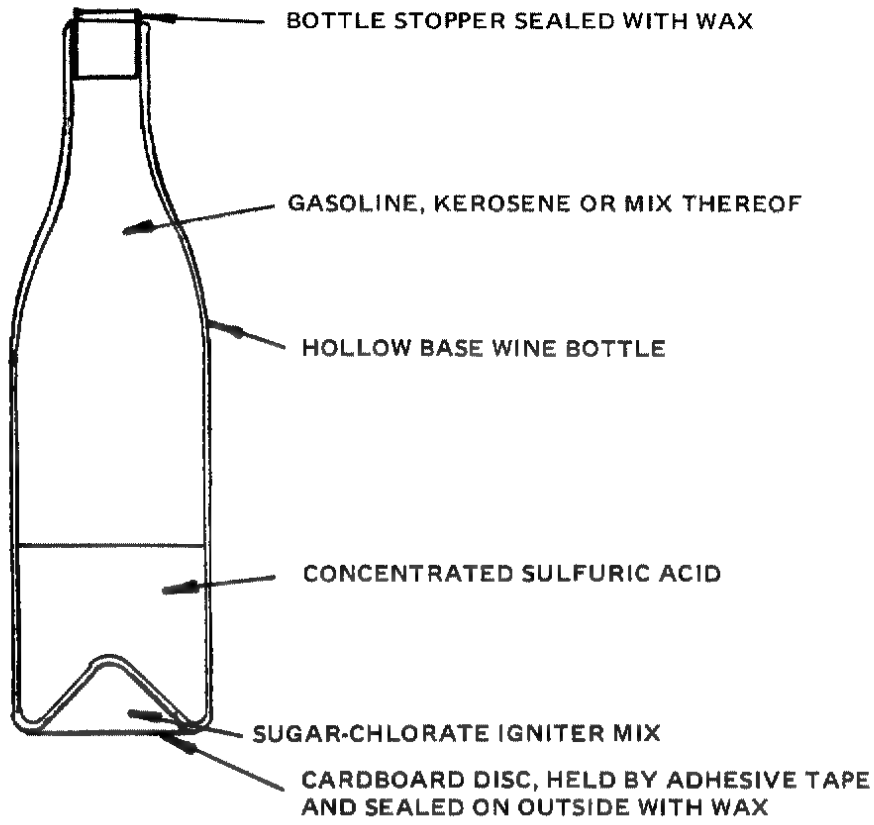




FUNCTIONING:

1. Prior to use, shake the sugar-chlorate solution.
2. Open the jar and pour the contents onto the cloth or paper wrapped around the gasoline gel bottle.
3. Note: the grenade may be used while the cloth is wet or dry; however the dry mix is sensitive to flame, spark, friction and shock, thus requiring extra care in handling.
4. Grip the bottle by the neck and throw like an old stick hand grenade.
5. Upon impact the bottle and the test tube(s) break, spilling the incendiary gel which comes into contact with the burning fuze material and bursts into flame; the chemical reaction of the acid and sugar-chlorate ignites the cloth.

EXPEDIENT INCENDIARY HAND GRENADE
Type 3



OPERATION:
1. Thoroughly wash and clean bottle with hot water.
2. Allow bottle to dry inside and out.
3. Pour acid carefully into the bottle, about 1/4 full.
4. Add gasoline/kerosene until full.
5. Close bottle and seal stopper.
6. Wash outside of bottle with water to remove all traces of acid and/or gasoline.
7. Fill hollow base with igniter mix.
8. Close bottle base with cardboard disc, tape over and seal.

FUNCTIONING:
1. Upon impact on hard surface the bottle breaks up, spilling the contents.
2. Contact of igniter mix and acid/gasoline filler causes ignition (acid ignites sugar/chlorate which in turn ignites gasoline).

aluminum and other common metals. It is used commercially for welding or burning holes in metal.

ADVANTAGES:

1. Readily available.
2. Relatively inexpensive.
3. Safe to carry and handle because of high ignition temperature.
4. Does not deteriorate in extended storage (if closed in can).
5. Burns well in any weather and under any ambient temperature.
6. Suitable to attack metallic targets such as vehicle engines, electric motors, transformers, boilers, pipelines, storage tanks, filing cabinets, etc.

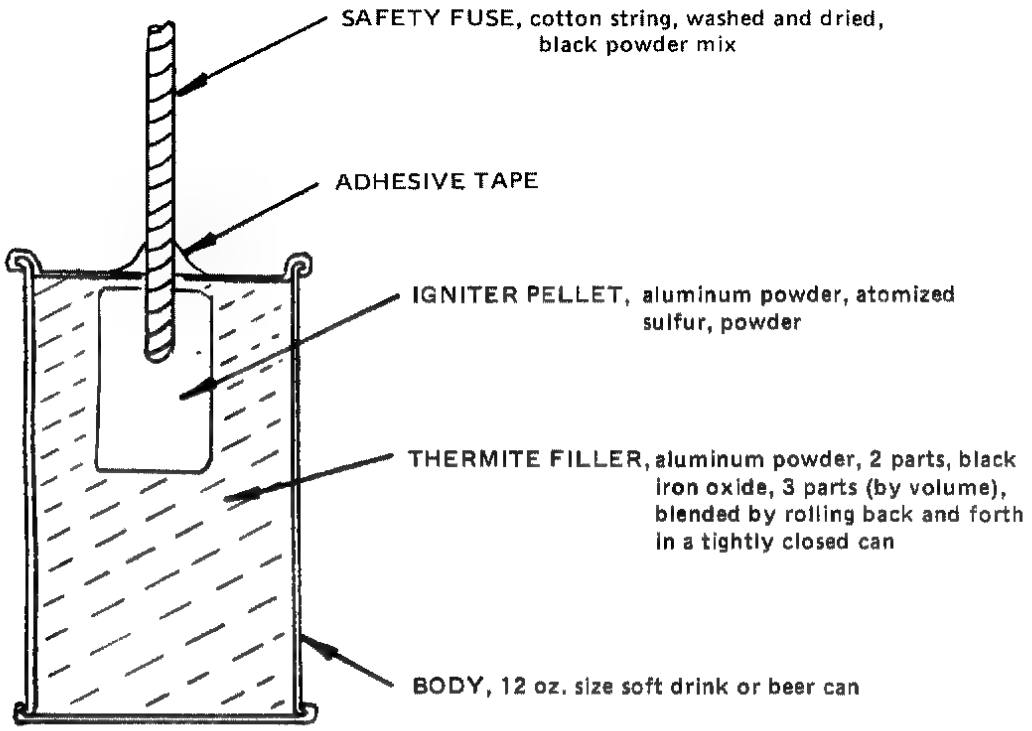
DISADVANTAGES:

1. Requires a strong igniter.
2. Not suitable on moderate or heavy wooden structures requiring persistent flames.

MATERIALS

1. Aluminum powder — No. 100 mesh size or

EXPEDIENT THERMITE INCENDIARY HAND GRENADE



OPERATION:

1. Remove top of can with can opener.
2. Straighten and remove burrs on can and top.
3. Thoroughly wash and dry can and top.
4. Prepare thermite mix.
5. Prepare igniter pellet.
6. Prepare safety fuse.
7. Place fuse into the igniter pellet.
8. Fill can with thermite mix.
9. Place igniter pellet into the thermite mix.
10. Make hole in the can top large enough to feed the fuse through.
11. Place can top over the thermite and igniter pellet so that the fuse protrudes through the hole in the top.
12. Secure the can top to the can with tape.
13. Seal the hole in the can top with tape and wax.

FUNCTIONING:

1. Ignite the fuse with a match.
2. Throw the grenade at the target.

finer; coarse powder is more difficult to ignite and is not as efficient. Maximum useable size is that of ground coffee.

2. Magnetic iron oxide — Fe_3O_4 — finely powdered, no coarser than coarse ground coffee. If iron oxide is not available then use other oxidizer substitute such as:
   Barium peroxide
   Lead, red
   Manganese dioxide
   Ferric sulfate
   Aluminum sulfate
   Anhydrous copper sulfate
   Anhydrous sodium sulfate

   Note: Use double quantity of substitute when replacing iron oxide.

EQUIPMENT

1. Measuring container or spoon.
2. Cylindrical container with tight fitting lid.
3. Cardboard can with metal ends.

PREPARATION:

1. Measure 2 parts by volume of aluminum and place into container.
2. Measure 3 parts by volume of iron oxide and place into the container.

3. Tighten lid on the container, turn it on its side and slowly roll back and forth until both powders are completely mixed.
4. The mixture is now ready for use or transfer to storage container.

Appendices

Mercury Fulminate Preparation

MERCURY	NITRIC ACID	ETHANOL	HYDROCHLORIC ACID
Hg	HNO_3	CH_3CH_2OH	HCL
Metallic, redistilled	(sp. den. 1.42)	90%	concentrated
10 gram	100 gram	79 gram	0.2 gram

1. Place specified quantity of mercury into 500 cc Erlenmayer flask.
2. Add specified quantity of nitric acid into flask.
3. Place flask under hood; do not stir or shake unnecessarily.
4. Place specified quantity of ethanol into 250 cc glass beaker.
5. Add specified quantity of hydrochloric acid to beaker contents.
6. Pour beaker contents into the flask.
   Note: The reaction starts in about 15 minutes with evolution of gas, then boiling and filling the reactor (flask) with fumes. These fumes are first white, then become brownish red as the reaction heat drives off nitric acid, then turn white again.
7. Mercury fulminate precipitates in the form of grayish-yellow crystals of good commercial quality.
8. After reaction completion leave the flask standing 30 minutes to allow the contents to cool to room temperature.
9. Slowly tilt the flask, decanting the liquid into a large pail full of water.
10. Dump the pail contents into sewer.
11. Place the beaker under the flask mouth and with a small stream of water wash the precipitate into the beaker.
12. Fill the empty flask full of tap water immediately, washing all traces of fulminate from the opening area.
13. Wash the raw fulminate by filling the beaker with distilled (or boiled and cooled) water, so that the fulminate is suspended in water.
14. Allow the fulminate to settle on the bottom, then decant off wash water.
15. Repeat the washing steps (13 & 14) 8 times; the last wash should be done with distilled water only.
16. Check the last wash water with litmus paper; the reaction should be neutral, if otherwise, continue washing until the fulminate is free of acid.
17. Fill the beaker of washed fulminate with water so that a layer of water covers all material.
18. Any solid material adhering to the beaker sides can be washed down with a little water.
19. Cover and label the beaker with date and lot number.
20. The resulting fulminate is of good military quality (98% pure). The crystal size is a mix which is not suitable for primer manufacture

but is adequate for expedient detonator filling.

21. Drying: Place folded filter paper into the glass funnel.
22. Bring the fulminate settled at the bottom of the beaker into suspension with a gentle swirling motion.
24. Pour beaker contents onto filter.
25. Wash the beaker thoroughly with tap water.
26. Remove the filter and fulminate from the funnel.
27. Unfold and place the filter on a shallow dish (small kitchen plate).
28. Place the filter and dish in a desiccator and dry for 24-48 hours.

    Note: The dry fulminate is now ready for detonator charging.

PREPARATION NOTES:

1. Pyrex glass coffee pots make a good substitute reactor flask.
2. Hood over kitchen stove which exhausts to the outside is quite suitable.
3. Ordinary, everyday drinking glasses are adequate for measuring (weighing) components.
4. When using kitchen sink for work area: do not pour spent acid into the sink. This may cause damage to the pipe and pipe joints. Pour the spent acids into a pail half-full of water and dump the contents later into outside sewer.
5. Practically all glass containers, jars, etc. may be used in an emergency for the preparation of fulminate. However, the Erlenmayer flask which is readily available and inexpensive is the preferred choice. Its shape is optimum for this type of work and it has been used by chemists for years and is highly recommended.
6. To measure (weigh) the required quantities, use a separate container for each component before combining them together.
7. Washing:
   [1] Fill the container with material to be washed about 2/3 full with water.
   [2] Bring all precipitated matter into suspension by moving the container in a gentle rotary motion.
   [3] Allow the matter to settle.
   [4] Pour off (decant) the water (over the precipitate) without disturbing the settled precipitate.
   [5] Repeat the washing process.
8. Sometimes the wash water (when tap water is is used) is slightly acid, hence the last couple of washes should be with distilled water.
9. The speed of dissolution of mercury in nitric acid depends on the ambient temperature; wait until all mercury dissolves and the liquid becomes emerald green in color.
10. When ethanol is added to the solution the color clears up to a pale yellow.

US Army Grenades

MODERN U.S. ARMY GRENADES

MODEL No.	REMARKS
Mk2	Cast iron body, type I.
M26	Sheet metal body, type II, filler with tetryl booster.
M26A1	M26 grenade with improved fragmentation sleeve.
M61	M26A1 grenade with safety clip. Modified sheet metal body of type II for M217 fuze (impact).
M57	M26A2 grenade with safety clip.
M33	Pre-notched sheet steel body of type III, fuze well threaded for M213 fuze (delay).
M67	M33 grenade with safety clip.
M59	M33 grenade with M217 fuze (impact).
M68	M33 grenade with M217 fuze and safety clip.

FRAGMENTATION GRENADE BODIES

The bodies of current U.S. Army fragmentation grenades are of 3 basic types:

A. Serrated, cast iron body,
used by: Mk 2 grenade.

B. Two piece sheet metal body with a fragmentation sleeve inside,
used by: M26
M26A1
M61.

Body shape modified to a slightly more spherical, and fuze well threaded for M213 and M217 fuzes,
used by: M26A2
M57.

C. Two piece pre-notched sheet steel body of welded construction, body form is almost spherical (re: MIL-G-14971),
used by: M33
M67
M59
M68.

COLOR CODING, U.S. ARMY HAND GRENADES

Type	Body Color	Markings
Training	Black	None
Practice	Blue	None
Offensive	Black w/ yell	
Practice	Blue	None
Offensive	Black w/ yellow band	Yellow
Fragmentation	Olive drab	Yellow
White phosphorus smoke	Gray w/ yellow band	Yellow

EXPEDIENT HAND GRENADES

Smoke, signal	Olive drab	Black	Riot, gas	Gray w/ red band	Red
Incendiary	Light red	Black	Note: Casualty inflicting grenades have yellow markings, gas filled grenades have red markings and all others use black markings.		
Illuminating	White or unpainted w/ white band	Black			

CHARACTERISTICS OF U.S. ARMY HAND GRENADES

TYPE	TRAINING	PRACTICE	OFFENSIVE	FRAGMENTATION	SMOKE	INCENDIARY
MODEL	Mk1A1	M30	Mk3A2	M26A1	M18	AN-M14
RANGE, meters	30	40	40	40	35	25
EFF. CASUALTY RADIUS, meters	none	None	2	15	–	–
COMPLETE GRENADE WEIGHT, grams	600	450	440	450	540	900
BODY MATERIAL	Cast Iron	Cast Iron	Fiber, asphalt impregnated	Sheet Metal	Sheet Metal	Sheet Metal, 28 Ga.
FILLER TYPE	None	Black Powder	TNT, flaked	Comp. B	Smoke Comp.	THERMATE TH3
FILLER WEIGHT, grams	–	1.4	227	164	326	750
FUZE TYPE	None	M205A1	M206A2	M204A2	M201A1	M201A1
DELAY, seconds	None	4.5	4.5	4.5	2	2
REFERENCE GRENADE			MIL-G-13483 MIL-G-13706 MIL-G-48737	MIL-G-14912 MIL-G-14789	MIL-G-12326	MIL-G-12297
FUZE		MIL-F-13424	MIL-F-13424	MIL-F-13424	MIL-F-10915 MIL-F-51353	MIL-F-10915 MIL-F-51353

Incendiary Terms Definitions

All definitions apply to incendiary systems only since some terms have an additional meaning in the explosives field.

DELAY MECHANISM — chemical, electrical or mechanical elements that provide a time delay. Elements may be used singly or in combination. They provide a predetermined, limited time interval before an incendiary starts to burn.

FUSE — A flexible fabric tube containing powder that is used to start fire at some remote (not necessarily distant) location. The material in the fuse burns and provides a time delay.

IGNITER — an intermediary charge between an initiator and an incendiary material. It is set aflame by the initiator and produces sufficient heat at high temperature to ignite the main incendiary. Igniters are fast burning and relatively short lived.

INCENDIARY MATERIAL — a material that burns with a hot flame for a long period of time. Its purpose is to set fire to a wooden structure or another combustible material.

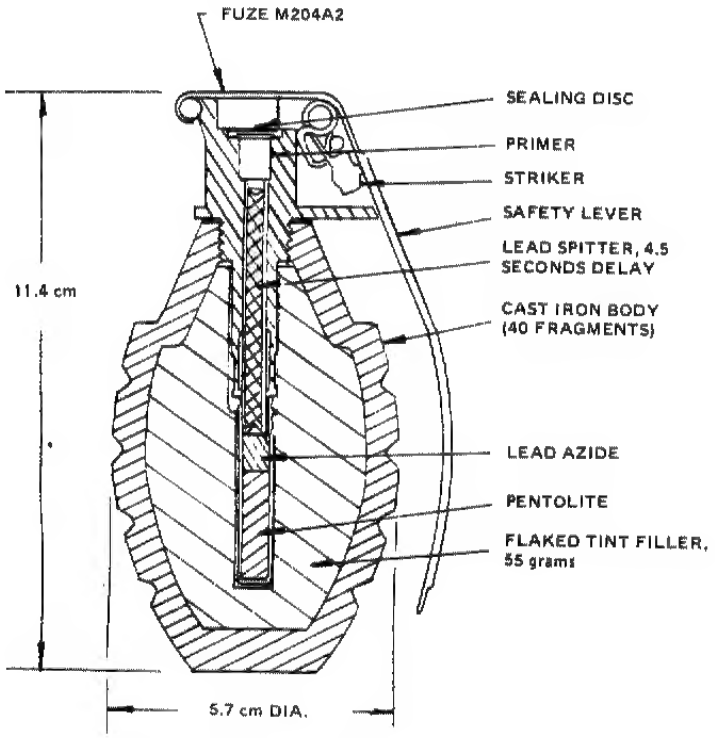
INITIATOR — the source providing the first fire in an incendiary system. The initiator is so sensitive that it can be set off with little energy. A match is an initiator.

SPONTANEOUS COMBUSTION — the outbreak of fire in combustible material occurring without application of direct spark or flame. The fire is the result of heat produced by the chemical reaction of certain oils.

THERMITE — an incendiary mixture of iron oxide flakes and aluminum powder that react chemically when ignited to form molten iron. Thermite is used to weld steel parts together or burn holes in steel.

Representative Military Grenades

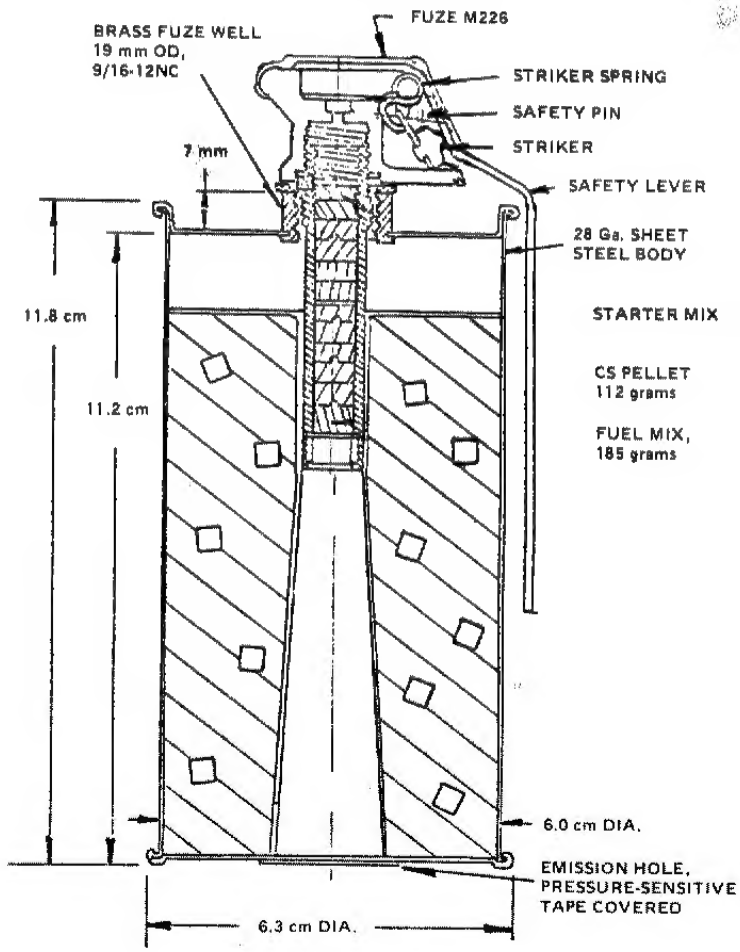
U.S. Mk2 FRAGMENTATION HAND GRENADE
(Presently authorized for Navy use only)



The Mk2 fragmentation grenade was being phased out of Army use as early as the late 1960's as stocks were depleted. It is presently used by a number of our smaller allies. Replacement of the Mk2 with the M26 began during the Korean War.

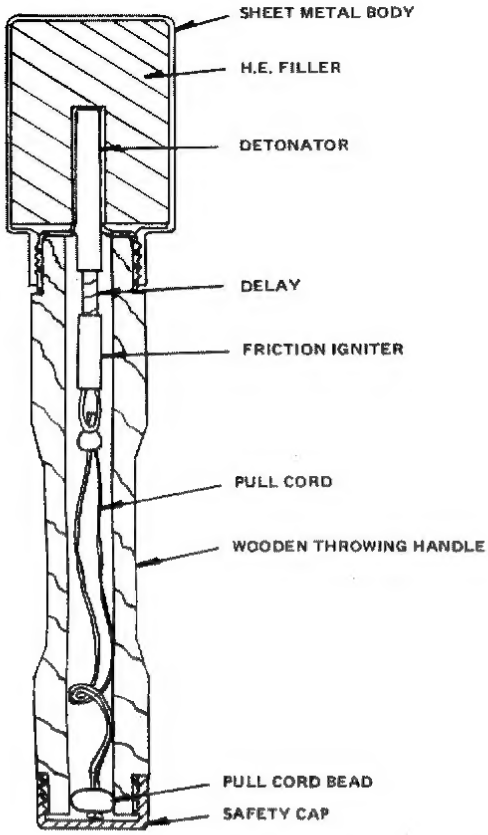
U.S. M54 CS HAND GRENADE

The CS agent has an emission time of 15 to 35 seconds, has a powerful tear-producing effect and irritates the upper respiratory passages, causing coughing, difficulty in breathing and chest tightness. A heavy concentration of CS causes nausea and vomiting. Incapacitation starts 15 to 30 seconds after application and continues for from



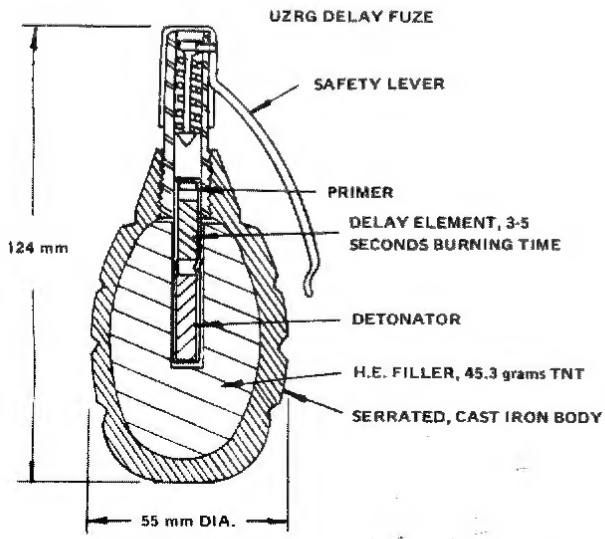
1/2 to several hours, depending on dosage. The CS agent is more persistent and has a more severe reaction than CN.

GERMAN Mod. 24 OFFENSIVE HAND GRENADE

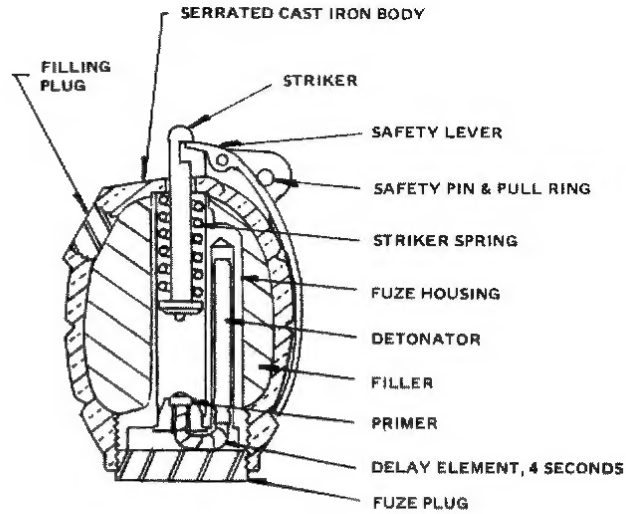


Although the wooden handle added to the grenade's overall weight, it actually increased its possible range and acted as protection for the fuze assembly. A fragmentation sleeve could be forcefully slipped over the body to convert the Model 24 to a defensive/fragmentation type grenade.

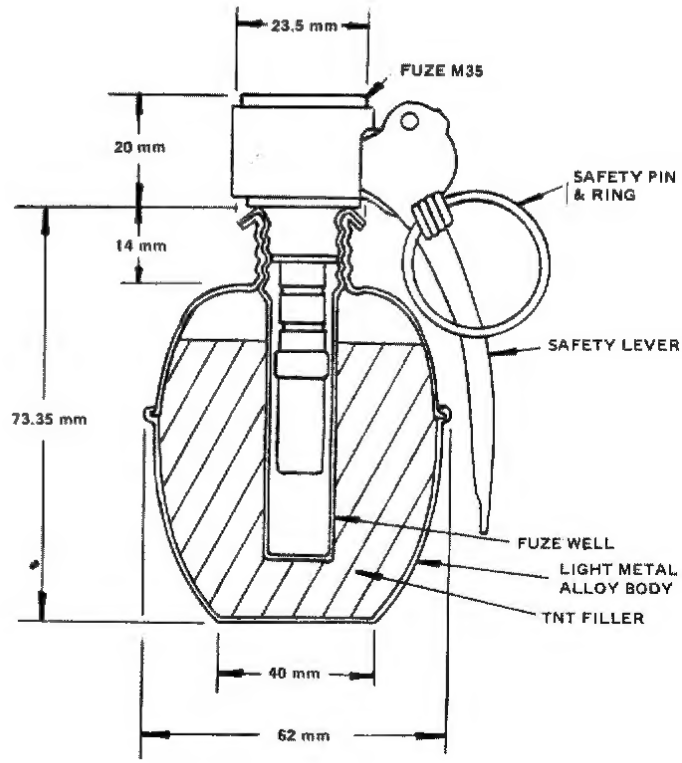
U.S.S.R. Mod. F1 FRAGMENTATION HAND GRENADE



BRITISH Mod. 36 M FRAGMENTATION HAND GRENADE



FRENCH Mod. 1937 OFFENSIVE HAND GRENADE



The Model 1937 hand grenade had an olive drab body and was unusual in that fuzes of two different lots were allowed in one lot of grenades.

DESERT PUBLICATIONS

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Now, one of America's leading ordnance designers reveals all the secrets of successful expedient hand grenade design and construction in this outstanding manual. These aren't just "stick some rocks in a beer can and add a firecracker" type grenades, but truly effective fragmentation and incendiary grenades with delayed detonation just like genuine military and police grenades. Different types of delays, fuzes vs. fuses, explosive charges, detonators, etc., are fully covered in an easily understand manner by the author of *Submachine Gun Designer's Handbook*.

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